Office Supreme Court, U.S.
FILED
DEC 23 1957
JOHN T. FEY, Clerk

No. 680

IN THE

United States Court of Appeals

FOR THE THIRD CIRCUIT

NO. 12,216

THE COLD METAL PRODUCTS COMPANY,
Plaintiff-Appellant,

v.

CRUCIBLE STEEL COMPANY OF AMERICA,
Defendant-Appellee.

Appeal from Judgment Entered February 13, 1957 by the District Court of the United States for the District of New Jersey, Civil Action No. 1231-52.

COLD METAL'S APPENDIX

WILLIAM H. WEBB
MORTON BURDEN, JR.
1220 Farmers Bank Building
Pittsburgh 22, Pa.
EDWARD J. O'MARA
1 Exchange Place
Jersey City 2, New Jersey
Attorneys for Plaintiff-Appellant.

WEBB, MACKEY & BURDEN
O'MARA, SCHUMANN, DAVIS & LYNCH
Of Counsel.

SMITH BROS. CO., INC., LAW PRINTERS, 430-438 BLVD. OF ALLIES, PITTSBURGH 19, PA.

TABLE OF CONTENTS OF COLD METAL'S APPENDIX

	PAGE
Docket Entries in Civil Action No. 1231-52	1a
Complaint in Civil Action No. 1231-52	6a
Defendant's Answer and Counterclaim	10a
Plaintiff's Reply to Defendant's Counterclaim	14a
Defendant's Supplemental Counterclaim	16a
Plaintiff's Reply to Defendant's Supplemental Counterclaim and Plaintiff's Counterclaim	18a
Defendant's Reply to Plaintiff's Counterclaim	23a

PORTIONS OF THE TRANSCRIPT OF PROCEEDINGS

Opening Statement of Defendant	29a
Stipulations of Counsel	29a
William B. Lockwood	31a
Ralph A. Freed	33a
Dr. George Sachs	51a
William H. Colvin	57a
Leroy Valette	63a
Dr. George Sachs	70a
Ralph A. Freed	77a

PLAINTIFF'S EXHIBITS

P-2	Agreement Between Cold Metal and Crucible, Dated September 30, 1946	80a
P-3	Montgomery Patent No. 2,072,122	91a
P-4	Montgomery Patent No. 2,087,065	109a
P-5	Montgomery Patent No. 2,214,107	113a
P-16	Exhibit P-16-1 through P-16-23 — Drawings of Crucible Mill	131a

DEFENDANT'S EXHIBITS

		PAGE
D-4	Cushwa Patent No. 904,605	177a
D-13-A	Portions of Exhibit D-13-A	181a
	Steckel Patent No. 1,857,670	181a
	Keeney and Ferm Patent No. 1,918,968	185a
	Steckel Patent No. 1,977,214	197a
D-21	Portions of Exhibit D-21	217a
	Article Appearing in "Steel" for June, 1932	217a
	Article Appearing in "The Iron and Steel Engineer" for January, 1933	219a
Opinion of the District Court		229a
Judgment of the District Court		247a
Order Amending Judgment		250a
Notice of Appeal by Crucible		251a
Notice of Appeal by Cold Metal		252a

COLD METAL'S APPENDIX

Docket Entries in Civil Action No. 1231-52

12-18-52	Complaint filed.
12-18-52	Summons issued.
12-18-52	Notice of Allocation (Newark) filed.
12-29-52	Summons returned served on 12-22-52, filed.
1-14-53	Consent order extending time to answer to 2-16-53, filed 1-13-53 (Modarelli) Notice mailed.
2-17-53	Answer and Counterclaim filed 2-16-53.
4-13-53	Stipulation allowing plaintiff's reply filed nunc pro tunc, filed.
4-13-53	Reply, filed.
9-16-53	Ordered pre-trial conference adjourned to next pre-trial calendar. (Modarelli) (9-15-53).
5-12-54	Ordered pre-trial conference adjourned to fall calendar. (Modarelli) (5-11-54).
7-13-54	Order to show cause fixing August 11th, 1954 as hearing date of application to restrain prosecution of action in Western District of Penna., and for leave to file supplemental counterclaim, filed 7-12-54. (Modarelli) Notice mailed.
7-19-54	Affidavit of William H. Webb in opposition to defendant's motions, filed 7-16-54.
8-13-54	Hearing on order to show cause re: to restrain prosecution in Western District of Pa. Decision Reserved. Hearing on application to file supplemental counterclaim. Decision Reserved. (Modarelli) (8-11-54)

Docket Entries in Civil Action No. 1231-52.

10-26-54	Motion to transfer action to the Western District of Pennsylvania, filed 10-25-54.
11- 1-54	Notice of motion to transfer action to the Western District of Pennsylvania, and acknowledgment of service, filed. (ret. 11-22-54). No brief submitted.
11-18-54	Affidavit of Kurt R. Vegel re motion to transfer action filed 11-17-54.
11-18-54	Affidavit of Charles E. Kenworthey in opposition to motion to transfer action filed 11-17-54.
11-18-54	Affidavit of Charles H. Walker filed 11-17-54.
11-23-54	Hearing on motion to transfer action to Western District of Penn. Decision Reserved. (Modarelli) 11-22-54.
11-29-54	Transcript of hearing on order to show cause heard on Aug. 11, 1954, filed 11-26-54.
11-29-54	Transcript of hearing on motion to transfer action to the Western District of Pennsylvania, filed 11-26-54.
12-23-54	Opinion filed 12-22-54. (Modarelli) (Motion to transfer Denied; defendant's motion to file supplemental counterclaim, Granted)
1-19-55	Notice of Settlement filed 1-18-55.
1-26-55	Order granting defendant's motion to file supplemental counterclaim; denying plaintiff's motion to transfer action to U.S. District Court for the Western District of Pennsylvania; enjoining plaintiff from prosecuting action in Pennsylvania, filed 1-25-55. (Modarelli) Notice mailed.

Docket Entries in Civil Action No. 1251-52.

1-31-55	Supplemental Counterclaim, filed.
1-31-55	Affidavit of service of supplemental counterclaim and order, filed.
2-17-55	Plaintiff's Reply to defendant's Supplemental Counterclaim and Plaintiff's Counterclaim, filed 2-16-55.
3- 9-55	Defendant's reply to plaintiff's counterclaim, filed 3-8-55
9-16-55	Pre-Trial Conference. (Modarelli) (9-15-55).
10- 4-55	Transcript of pre-trial conference, filed 10-3-55.
3-23-56	Trial without Jury before Hon. Alfred E. Modarelli (3-22-56). Trial adjourned to 3-23-56.
3-26-56	Motion to amend counterclaim filed, 3-23-56.
3-26-56	Trial continued: 3-23-56. Ordered motion to amend counterclaim, Granted. Trial adjourned to 3-27-56.
3-28-56	Trial continued: (3-27-56). Trial adjourned to 3-28-56.
3-29-56	Trial continued: (3-28-56). Trial adjourned to 3-29-56.
4- 2-56	Trial continued: (3-29-56). Trial adjourned to 4-3-56.
4- 4-56	Trial continued: (4-3-56). Trial adjourned to 4-4-56.
4- 5-56	Trial continued: (4-4-56). Application by plaintiff for leave to withdraw exhibits P-7 thru P-14 and P-17 granted. Trial adjourned to 4-5-56.

Docket Entries in Civil Action No. 1231-52.

4- 6-56	Trial continued: (4-5-56). Trial adjourned to 4-6-56.
4-10-56	Trial continued: (4-6-56). Proposed findings of fact and conclusions of law to be submitted. Decision Reserved.
6- 6-56	Stipulation re editorial corrections in the official transcript, filed 6-5-56.
8-17-56	Transcript of trial filed (5 volumes).
12-31-56	Opinion filed 12-28-56. (Modarelli).
1-14-57	Notice of motion by plaintiff for settlement of judgment, and acknowledgment of service, filed 1-11-57 (ret. 1-28-57) (No brief submitted)
1-29-57	Hearing on plaintiff's motion for settlement of judgment. Decision Reserved. (Modarelli) (1-28-57)
2- 4-57	Transcript of hearing on motion for settlement of terms of judgment, filed.
2-13-57	Final judgment declaring certain claims valid and other claims invalid; dismissing all counterclaims not specifically covered herein; declaring certain claims infringed by defendant; referring the question of damages re: infringement to a Special Master and finding in favor of the plaintiff, The Cold Metal Products Company, in the sum of $622,771.58, and against the defendant, Crucible Steel Company of America, with costs filed 2-8-57. (Modarelli) Notice mailed.

Docket Entries in Civil Action No. 1231-52.

2-18-57	Consent Order Amending Judgment filed. (Modarelli) Notice mailed.
2-18-57	Notice of Appeal filed.
2-18-57	Consent Order for Stay Upon Appeal filed 2-18-57. (Modarelli) Notice mailed.
2-18-57	$250.00 deposited in Registry in lieu of appeal bond.
2-18-57	Clerk's Certificate of Cash Deposit filed.
2-18-57	Copies of notice of appeal sent to O'Mara, Schumann, Davis & Lynch, Esqs., and Clerk, U.S.C.A.
2-19-57	Warrant for Satisfaction of Judgment in the sum of $199,570.27 ONLY, as appears in paragraph 1 of judgment, filed.
2-25-57	Notice of Appeal, filed 2-21-57.
2-25-57	Copies forwarded to Pitney, Hardin & Ward, Esqs., and to Clerk, USCA.
2-25-57	$250.00 deposited in Registry in lieu of Appeal Bond.
2-25-57	Clerk's Certificate of cash deposit, filed.

Complaint in Civil Action No. 1231-52.

For its Complaint, plaintiff says:

1. Plaintiff, The Cold Metal Products Company, is a corporation organized and existing under the laws of the State of Ohio, having a place of business at Youngstown, Ohio. Defendant, Crucible Steel Company of America, is a corporation organized and existing under the laws of the State of New Jersey, having a regular and established place of business at Harrison, New Jersey. The matter in controversy exceeds, exclusive of interest and costs, the sum of Three Thousand Dollars ($3,000.00).

2. On or about September 30, 1946, plaintiff and defendant entered into a license agreement, a true and correct copy of which is marked Exhibit A and attached hereto and made a part hereof.

3. Under said agreement, plaintiff granted to defendant a non-exclusive right and license under certain United States Letters Patent set forth therein (a) to make or have made for its own use mills and equipment coming under the United States Letters Patent set forth therein, (b) to own and use said mills and equipment, (c) to practice processes coming within the scope of said patents throughout the United States, its territories and possessions, and (d) to use and sell the products of said mills, equipment and processes anywhere in the world. In return for the rights granted by plaintiff to the defendant, defendant agreed to pay to plaintiff certain royaltics on products rolled on mills or equipment under said United States Letters Patent, as set forth in Section III of said agreement.

4. Pursuant to the rights granted to it under said agreement, defendant made or had made for its own use a two-stand reversing hot rolling mill and equipment coming under said United States Letters Patent and has used and continues to use said mill and equipment and has practiced and continues to practice processes coming within the scope of said United States Letters Patent and has used and sold and continues to use and sell the products of said mill, equipment and processes.

5. For the period commencing April 1, 1949 to November 30, 1951, defendant paid to plaintiff certain royalties asserted by defendant to be due pursuant to the terms of said agreement, but the amounts actually paid by defendant were computed and determined by defendant on entirely incorrect bases, as a consequence of which the royalties actually paid by defendant were far less than the amounts due pursuant to the terms of said agreement. In addition, during said period from April 1, 1949 to November 30, 1951, defendant used said mill and equipment coming under said United States Letters Patent and practiced processes coming within the scope of said Letters Patent in the rolling of products subsequently used or sold by the defendant and which defendant failed to report to plaintiff and to pay the royalties due thereon pursuant to the terms of said agreement. Plaintiff is without sufficient information to enable it to allege the exact amount due pursuant to said agreement for the period from April 1, 1949 to November 30, 1951 and, therefore, seeks discovery and an accounting herein to enable it to ascertain the exact amount of the additional royalties due to it pursuant to the terms of said agreement.

6. Defendant, from and after November 30, 1951, has used and continues to use said mill and equipment coming under said United States Letters Patent and has practiced and continues to practice processes coming within the scope of said patents and has used and sold the products of said mill, equipment and processes, but, nevertheless, has failed and refused and continues to fail and refuse to pay to plaintiff the royalties due pursuant to the terms of said agreement. Plaintiff is without sufficient knowledge and information to enable it to state the exact amount of the royalties due for the period subsequent to November 30, 1951, and, therefore, seeks discovery and an accounting in respect thereof.

WHEREFORE, plaintiff demands:

A. Discovery and an accounting in respect of the additional royalties due plaintiff pursuant to said agreement for the period from April 1, 1949 to November 30, 1951.

B. Judgment in its favor for the additional royalties found to be due plaintiff under said agreement for the period from April 1, 1949 to November 30, 1951, together with interest at the rate of six percent (6%) on any such additional royalties for the period from the date when such additional royalties became due pursuant to the terms of said agreement to the date of the entry of a final judgment herein.

C. Discovery and an accounting in respect of the royalties due plaintiff pursuant to said agreement for the period subsequent to November 30, 1951.

D. Judgment in its favor for the total amount of the royalties due pursuant to the terms of said agree-

ment for the period subsequent to November 30, 1951, together with interest thereon at the rate of six percent (6%) from and after the date when each such royalty payment became due pursuant to the terms of said agreement.

E. Judgment for costs and reasonable attorneys' fees.

F. Such other and further relief as to this Court may seem meet and proper.

THE COLD METAL PRODUCTS COMPANY

By EDWARD J. O'MARA

Edward J. O'Mara
1 Exchange Place
Jersey City, New Jersey

WILLIAM H. WEBB
1220 Farmers Bank Building
Pittsburgh 22, Pennsylvania,

Attorneys for Plaintiff.

O'MARA, SCHUMANN, DAVIS & LYNCH,
WEBB, MACKEY & BURDEN,
Of Counsel.

December 16, 1952.

Defendant's Answer and Counterclaim.

Answering the complaint:

1. Defendant admits the averments of paragraph 1

2. Defendant admits the averments of paragraph 2.

3. Defendant avers that the agreement, copy of which is annexed to the complaint, speaks for itself and refers to the same for a more complete statement of the contents thereof.

4. Defendant avers that it has made for its own use and installed at its steel works at Midland, Pennsylvania, a so-called "hot strip mill" for rolling hot metal ingots into long lengths of continuous strip, said mill comprising a single stand universal mill for rough rolling said ingots into rectangular slabs, and a single stand reversing hot strip mill for hot rolling said slabs into continuous strip, and roll tables in advance of said universal mill and between said universal mill and said reversing hot strip mill and extending beyond said reversing hot strip mill, for conveying said ingots, slabs and strip. Defendant further avers that said mill was first placed in commercial operation on or about April 1, 1949, and that between said date and shortly prior to November 30, 1951, said mill, and certain processes practiced by defendant in connection therewith, may have come within the scope of certain of the patents set forth in said agreement. Defendant denies each and every other allegation of said paragraph 4.

5. Defendant avers that for the period commencing April 1, 1949 to November 30, 1951, it paid to plaintiff all royalties due to plaintiff under said agreement. Defend-

ant denies each and every other allegation in said paragraph 5.

6. Defendant denies each and every allegation contained in paragraph 6 of the complaint.

7. Further answering said complaint, defendant avers that prior to November 30, 1951, three of the patents under which defendant was licensed by said agreement had expired and their inventions had passed into the public domain, and that prior to November 30, 1951, defendant had made certain changes and alterations in and to its said hot strip mill and in and to the process or processes employed in the operation of said mill, with the result that on or after November 30, 1951, defendant at no time made or had made for it mills and equipment coming under plaintiff's said patents, or practiced processes coming within the scope of plaintiff's said patents, or rolled steel or any other product on mills or equipment coming within the scope of plaintiff's said patents, or any of them.

Defendant's Counterclaim.

COUNTERCLAIM

8. Defendant and counterclaimant, Crucible Steel Company of America, is a corporation organized and existing under the laws of the State of New Jersey, having a regular and established place of business at Harrison, New Jersey. Plaintiff, The Cold Metal Products Company, is a corporation organized and existing under the laws of the State of Ohio, having a place of business at Youngstown, Ohio. The matter in controversy exceeds, exclusive of interest and costs, the sum of Three Thousand Dollars ($3,000.00).

9. Defendant and counterclaimant repeats all of the allegations of paragraph 3 through paragraph 7 of its Answer hereinabove set forth.

10. Defendant and counterclaimant avers that in August, 1950, certain changes were made in the price of stainless steel rolled on said hot strip mill, but that said price changes were not brought to the attention of its accounting department and accordingly, that defendant and counterclaimant reported and paid to plaintiff Nine Thousand Four Hundred and Thirty-five Dollars and twenty-four Cents ($9,435.24) in excess of the royalties due and owing to plaintiff under said agreement, in the period August 1, 1950 to November 30, 1951.

WHEREFORE, defendant and counterclaimant prays:

1. That the complaint herein be dismissed;

2. That the counterclaim herein be sustained and that judgment be given in favor of defendant and counterclaimant in the amount of Nine Thousand Four Hundred and Thirty-five Dollars and twenty-four Cents ($9,435.24); and

3. That defendant and counterclaimant be granted such other and further relief as this Court may deem just, including its costs and reasonable attorneys' fees in this action.

PITNEY, HARDIN & WARD

By s/ FRANK C. O'BRIEN

Attorneys for Defendant and Counterclaimant

744 Broad Street

Newark, New Jersey

Of Counsel:

CHARLES H. WALKER

FISH, RICHARDSON & NEAVE

20 Exchange Place

New York 5, N. Y.

RAYMOND J. McELHANNON

WARD, CROSBY & NEAL

225 Broadway

New York 7, N. Y.

Service of a copy of the within Answer and Counterclaim is hereby acknowledged this 16th day of February, 1953.

s/ O'MARA, SCHUMANN, DAVIS & LYNCH

O'Mara, Schumann, Davis & Lynch

Attorneys for Plaintiff

Plaintiff's Reply to Defendant's Counterclaim.

In reply to defendant's counterclaim, plaintiff says:

1. Plaintiff admits the allegations of Paragraph 8.

2. In reply to Paragraph 9, plaintiff admits (a) that defendant made or had made for its own use and installed in its Steel Works at Midland, Pennsylvania a hot strip mill for rolling hot metal ingots into long lengths of continuous strip, (b) that said mill comprises a roughing mill for rough rolling ingots into rectangular breakdowns or slabs, a reversing finishing mill for rolling the slabs or breakdowns into strip-like form, roll tables in advance of the roughing mill and between the roughing mill and the finishing mill and extending beyond the finishing mill for conveying the ingots, slabs, breakdowns or strip, guides, pinch rolls, and other equipment, (c) that said mill was first placed in regular commercial operation on or about April 1, 1949, (d) that, between April 1, 1949 and November 30, 1951, as well as subsequent to November 30, 1951, said mill and the rolling processes practiced by defendant in connection therewith did, in fact, come within the scope of certain of the patents set forth in the agreement of September 30, 1946, (e) that, for the period commencing April 1, 1949 and ending November 30, 1951, defendant paid certain of the royalties to plaintiff under said agreement, and (f) that, prior to November 30, 1951, three of the patents under which defendant was licensed by said agreement had expired. Plaintiff denies (a) that, for the period April 1, 1949 to November 30, 1951, defendant paid to plaintiff all royalties due to plaintiff under said agreement of September 30, 1946, (b) that the defendant made any changes or alterations in or to its hot strip mill or

in or to the processes employed in the operation of the mill resulting in the defendant being relieved of its obligation to pay royalties under said agreement, (c) that defendant, at no time on or after November 30, 1951, made or had made for it mills and equipment coming under the licensed patents or practiced processes coming within the scope of the licensed patents, or rolled steel or any other product on mills or equipment coming within the scope of the licensed patents. Plaintiff avers (a) that defendant's hot strip mill and processes practiced by the defendant in connection therewith, both prior to November 30, 1951 and subsequent thereto, were covered by and came within the scope of one or more of the unexpired patents set forth in said agreement of September 30, 1946, and (b) that such changes or alterations as defendant may have made in and to said hot strip mill or the processes employed in the operation of said mill did not modify, in any way, the essential characteristics thereof or take said mill or processes outside the scope of the claims of said licensed patents. Plaintiff denies each and every other allegation of Paragraph 9 of defendant's counterclaim not specifically covered by the foregoing admissions, denials and averments.

3. In reply to Paragraph 10, plaintiff denies each and every one of the allegations contained therein and avers that, on the contrary, defendant has failed and refused to pay all of the royalties due under said license agreement for the period April 1, 1949 to November 30, 1951, with the result that defendant still owes to the plaintiff for the period April 1, 1949 to August 31, 1951 royalties in excess of $254,867.27 and royalties for the period subsequent to August 31, 1951 in an amount not

now known to plaintiff and for which plaintiff seeks discovery and an accounting.

WHEREFORE, plaintiff prays that defendant's counterclaim be dismissed and that it be granted such other and further relief as this Court may deem proper, including its costs and reasonable attorneys' fees in this action.

EDWARD J. O'MARA
WILLIAM H. WEBB
Attorneys for Plaintiff

O'MARA, SCHUMANN, DAVIS & LYNCH
WEBB, MACKEY & BURDEN
Of Counsel

Defendant's Supplemental Counterclaim.

11. Jurisdiction of this counterclaim is founded upon 28 U.S.C. §§ 1338, 2201.

12. By notice dated March 2, 1953, and effective April 1, 1953, subsequent to February 16, 1953, when defendant's original answer and counterclaim in this action were served and filed, defendant, pursuant to and in compliance with Section XI of the license agreement of September 30, 1946, a copy of which is annexed to the complaint herein, cancelled said license agreement.

13. By notice dated July 1, 1954, plaintiff notified defendant that its continued use subsequent to April 1, 1953 of a certain steel rolling mill was charged by it to infringe United States patents 2,072,122, 2,087,065, and 2,214,107 owned by plaintiff.

14. None of the claims of the above patents have ever been infringed by defendant.

15. Each of the above patents is invalid because the subject matter of the patent was obvious at the time

the invention was allegedly made to persons having ordinary skill in the art to which that subject matter pertains, in view of the state of the art then existing.

WHEREFORE, defendant prays

1. For a declaratory judgment that United States patents 2,072,122, 2,087,065, and 2,214,107 are invalid and have not been infringed by defendant.

2. For an injunction restraining plaintiff or anyone in privity therewith from instituting any suit for infringement against defendant or anyone in privity with defendant under any or all of United States patents 2,072,122, 2,087,065, and 2,214,107.

3. For an award of costs to defendant, and reasonable attorneys' fees.

4. For such other and further relief to defendant as the Court may deem proper.

PITNEY, HARDIN & WARD
Attorneys for Defendant
By FRANK C. O'BRIEN

Dated: January 28, 1955

Of Counsel:

CHARLES H. WALKER,
HENRY J. ZAFIAN
FISH, RICHARDSON & NEAVE,
20 Exchange Place,
New York 5, N. Y.

RAYMOND J. McELHANNON
WARD, NEAL, HASELTON, ORME & McELHANNON,
225 Broadway,
New York 7, N. Y.

Plaintiff's Reply to Supplemental Counterclaim.

Service of a copy of the within Supplemental Counterclaim is hereby acknowledged this .... day of January, 1955.

O'MARA, SCHUMANN, DAVIS & LYNCH
Attorneys for Plaintiff

Plaintiff's Reply to Defendant's Supplemental Counterclaim and Plaintiff's Counterclaim.

For its reply to defendant's supplemental counterclaim, plaintiff says:

1. Plaintiff admits the allegations of Paragraph 11 of defendant's supplemental counterclaim.

2. Plaintiff admits the allegations of Paragraph 12 of defendant's supplemental counterclaim.

3. Plaintiff admits that, by letter dated July 1, 1954, it notified defendant that defendant's continued use, subsequent to April 1, 1953, of a certain steel rolling mill was charged by plaintiff to infringe United States Letters Patent Nos. 2,072,122, 2,087,065, and 2,214,107, owned by plaintiff, but avers that, as early as April, 1952, defendant was notified by plaintiff that defendant's hot rolling mill and the operation thereof were within the scope of one or more of said Letters Patent, that, subsequent to April 1, 1953 and prior to October 13, 1953, defendant was notified of plaintiff's charge of infringement of said Letters Patent by reason of defendant's continued use, subsequent to April 1, 1953, of said steel rolling mill, that, on October 13, 1953, defendant was again notified and advised of plaintiff's position that the continued use of said mill subsequent to April 1, 1953 constituted an infringement upon said Letters Patent.

and that, in the subsequent dealings between the parties looking toward a settlement of "all issues, claims and demands by Cold Metal against Crucible," defendant was apprised and aware of plaintiff's position that defendant's continued use of said rolling mill subsequent to April 1, 1953 constituted an infringement upon said Letters Patent owned by plaintiff.

4. Plaintiff denies the allegations set forth in Paragraph 14 of defendant's supplemental counterclaim.

5. Plaintiff denies each and every of the allegations contained in Paragraph 15 of defendant's supplemental counterclaim.

Counterclaim

For its Counterclaim against the defendant, Crucible Steel Company of America, plaintiff says:

6. Plaintiff, The Cold Metal Products Company, is a corporation organized and existing under the laws of the State of Ohio, having a place of business at Youngstown, Ohio. Defendant, Crucible Steel Company of America, is a corporation organized and existing under the laws of the State of New Jersey, having a regular and established place of business at Harrison, New Jersey. The matter in controversy exceeds, exclusive of interest and costs, the sum of Three Thousand Dollars.

7. The jurisdiction of this Court is founded on the fact that this counterclaim constitutes an action arising under the Patent Laws of the United States for infringement of United States Letters Patent, and on Title 28, United States Code, Section 1338. Venue is based upon Title 28, United States Code, Section 1391.

8. Plaintiff, for some years past and at all times hereinafter complained of, was and now is the owner of the entire right, title and interest in and to each of the following United States Letters Patent and any and all rights of recovery for infringement thereof:

Patent No.	Patentee	Date of Issue
2,072,122	Montgomery	March 2, 1937
2,087,065	Montgomery	July 13, 1937
2,214,107	Montgomery	September 10, 1940

9. On or about September 30, 1946, plaintiff and defendant entered into a license agreement whereby plaintiff granted to defendant a nonexclusive right and license under certain United States Letters Patent, including the patents set forth in Paragraph 8 hereof, (a) to make, use and have made for its own use mills and equipment coming under said Letters Patent, (b) to own and use said mills and equipment, (c) to practice processes coming within the scope of said Letters Patent throughout the United States, its territories and possessions, and (d) to use and sell the products of such mills, equipment and processes. In return for the rights granted by plaintiff to the defendant, defendant agreed to pay to plaintiff certain royalties on products rolled on mills or equipment under said Letters Patent, as set forth in Section III of said agreement.

10. Pursuant to the rights granted to it under said agreement, defendant made or had made for its own use a two-stand reversing hot rolling mill and equipment coming under certain Letters Patent recited in said agreement, including the patents identified in Paragraph 8 hereof, and has used and continues to use said mill and equipment, and has practiced and continues to practice

processes coming within the scope of the Letters Patent identified in Paragraph 8 hereof, and has used and sold and continues to use and sell the products of said mill, equipment and processes. For the period from April 1, 1949 to November 30, 1951, defendant paid to plaintiff certain royalties asserted by defendant to be due, pursuant to the terms of said license agreement. From and after November 30, 1951, defendant, although it has continued to use said mill and equipment coming under said Letters Patent set forth in Paragraph 8 hereof, and has practiced and continues to practice processes coming within the scope of said Letters Patent, nevertheless, failed and refused to pay to plaintiff the royalties due, pursuant to the terms of said agreement, prior to April 1, 1953.

11. By notice, dated March 2, 1953 and effective April 1, 1953, defendant cancelled said license agreement, but, nevertheless, since April 1, 1953, has infringed upon each of said Letters Patent identified in Paragraph 8 hereof by using said hot rolling mill and equipment, which embodies inventions covered by said Letters Patent, and by using processes or methods covered by said Letters Patent, and is still infringing upon said Letters Patent No. 2,214,107 and will continue to do so unless enjoined by this Court.

12. Plaintiff and its predecessor have placed the required statutory notice on all mills manufactured and sold by or for them under said Letters Patent and plaintiff has given both written and oral notice to defendant of its infringement thereof; but, despite such notices of infringement, defendant has persisted in its infringement upon said Letters Patent.

13. The inventions of each of said Letters Patent are of great utility and value and have been extensively applied to practical use by defendant and by others. The inventions of said Letters Patent have effected a marked advance in the metal rolling art and the public generally, and particularly this defendant, have benefited greatly thereby. Licenses have been granted by plaintiff and its predecessor under the inventions covered by said Letters Patent to various steel manufacturers, including this defendant, and said licensees have paid substantial sums thereunder.

WHEREFORE, plaintiff prays:

A. For both preliminary and final injunctions against further infringement of said Letters Patent No. 2,214,107.

B. For an order holding each of Letters Patent Nos. 2,072,122, 2,087,065 and 2,214,107 valid and infringed by defendant.

C. For an accounting of profits and damages arising out of defendant's infringement of each of said Letters Patent Nos. 2,072,122, 2,087,065 and 2,214,107.

D. For an award of costs to plaintiff, including reasonable attorneys' fees.

E. For such other and further relief as the Court may deem proper.

THE COLD METAL PRODUCTS COMPANY
By EDWARD J. O'MARA
WILLIAM H. WEBB
Attorneys for Plaintiff

Defendant's Reply to Plaintiff's Counterclaim.

Defendant's Reply to Plaintiff's Counterclaim

Defendant, CRUCIBLE STEEL COMPANY OF AMERICA, for its reply to the counterclaim contained in plaintiff's reply to defendant's supplemental counterclaim, dated February 15, 1955, and filed herein February 16, 1955, alleges as follows:

1. Defendant admits the allegations of paragraph 6.

2. Defendant admits the allegations of paragraph 7.

3. Defendant is without knowledge or information sufficient to form a belief as to the truth of the averments of paragraph 8.

4. Replying to paragraph 9, defendant admits that it entered into a license agreement with plaintiff on or about September 30, 1946, but avers that the agreement, a copy of which is annexed to the complaint, speaks for itself and refers to the same for a more complete statement of its contents.

5. Replying to paragraph 10, defendant admits and avers that it made or had made for its own use and installed at its steel works at Midland, Pennsylvania, a so-called "hot strip mill" for rolling hot metal ingots into long lengths of continuous strip, said mill comprising a single stand universal mill for rough rolling said ingots into rectangular slabs and said slabs into relatively long and thin breakdowns, and a single stand reversing hot strip mill for hot rolling said breakdowns into continuous strip, and roll tables in advance of said universal mill and between said universal mill and said reversing mill and extending beyond said reversing hot strip mill, for conveying said ingots, slabs, breakdowns and strip. De-

fendant further avers that said mill was first placed in commercial operation on or about April 1, 1949, and that between said date and shortly prior to November 30, 1951, said mill and certain processes practiced by defendant in connection therewith, may have come within the scope of certain of the patents set forth in said agreement. Defendant further avers that prior to November 30, 1951, defendant had made certain changes and alterations in and to its said hot strip mill and in and to the process or processes employed in the operation of said mill, with the result that on or after November 30, 1951, defendant at no time made, or had made for it, mills and equipment coming under or covered by plaintiff's said patents, or practiced processes coming within the scope of plaintiff's said patents, or rolled steel or any other product on mills or equipment coming within the scope of plaintiff's said patents, or any of them. Defendant further avers that for the period April 1, 1949 to November 30, 1951, it paid to plaintiff all royalties due to plaintiff under said license agreement and that no royalties accrued under said agreement for defendant's operations subsequent to November 30, 1951. Except as herein admitted or averred, defendant denies each and every allegation in paragraph 10 of plaintiff's counterclaim.

6. Replying to paragraph 11, defendant admits that by notice, dated March 2, 1953, and effective April 1, 1953, it cancelled said license agreement, and avers that such written notice was pursuant to the terms of Section XI of the said license agreement. Defendant denies each and every other allegation contained in paragraph 11 of plaintiff's counterclaim.

– Defendant's Reply to Plaintiff's Counterclaim.

7. Defendant is without knowledge or information sufficient to form a belief as to the truth of the averment of paragraph 12 of plaintiff's counterclaim that plaintiff and its predecessor have placed the required statutory notice on all mills manufactured and sold by or for them under the patents in suit; defendant admits that written notice of defendant's alleged infringement of the three patents here in suit was given by plaintiff by letter dated July 1, 1954. Defendant denies each and every other allegation of said paragraph 12.

8. Replying to paragraph 13, defendant admits that it entered into the license agreement with plaintiff dated September 30, 1946, a copy of which is annexed to the complaint, and paid plaintiff substantial sums thereunder. Except as to the said license agreement between plaintiff and defendant, defendant is without knowledge or information sufficient to form a belief as to the truth of the averment of paragraph 13 of plaintiff's counterclaim that licenses have been granted by plaintiff and its predecessor under one or more of the patents in suit to steel manufacturers and that said licensees have paid substantial sums thereunder. Except as herein expressly admitted, defendant denies each and every allegation of said paragraph 13.

Further Replying to Plaintiff's Counterclaim

9. Defendant avers that each of the three patents identified in paragraph 8 of plaintiff's counterclaim, is invalid and void because:

(a) The alleged invention thereof was known or used by others in this country, and was patented or described in printed publications be-

fore the invention thereof by the applicant for said patent;

(b) The alleged invention thereof was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for said patent;

(c) The applicant for said patent did not invent the subject matter claimed therein;

(d) Before the applicant's alleged invention of said patent, the same was made in this country by another who had not abandoned, suppressed or concealed it; and

(e) At the time of the alleged invention of said patent, the same was obvious to persons having ordinary skill in the art to which the subject matter of said patent pertains.

10. Defendant avers that each of the three patents identified in paragraph 8 of plaintiff's counterclaim is invalid and void for the following additional reasons:

(a) As to each of said patents because the claims thereof are indefinite, ambiguous and uncertain and do not particularly point out and distinctly claim the part, combination, process or improvement which the patentee claims as his alleged invention or discovery;

(b) As to patent 2,072,122 because the claims thereof are functional and purport to monopolize exhausted combinations of elements;

(c) As to patents 2,214,107 and 2,087,065 because the claims thereof cover obvious manipulations of machines disclosed in prior patents to others, and because said claims, if construed to cover defendant's operations, are directed to subject matter not disclosed or claimed in the application for said patent as originally filed; and

(d) As to each of said patents, because the claims thereof purport to monopolize mere aggregations of elements or process steps.

11. As to each of the three patents identified in paragraph 8 of plaintiff's counterclaim, defendant avers that by reason of the proceedings in the United States Patent Office during the prosecution of the application which resulted in each said patent, and by reason of the admissions and representations therein made by or on behalf of the applicant in order to induce the granting of said patent, and by reason of the revisions in the scope of claims made therein in avoidance of prior art citations, plaintiff is estopped to claim for said patent, a construction, were the same otherwise possible, such as would cause said patent to cover or include the acts of defendant of which plaintiff complains.

12. Defendant avers that the claims of each of said patents in suit, even if valid and if given whatever scope the art permits, do not cover the apparatus and the methods used by defendant and complained of herein.

Defendant's Reply to Plaintiff's Counterclaim.

WHEREFORE, defendant prays

1. For a declaratory judgment that United States patents 2,072,122, 2,087,065, and 2,214,107 are invalid and have not been infringed by defendant.

2. For an injunction restraining plaintiff, or anyone in privity with plaintiff, from instituting any suit for infringement against defendant, or anyone in privity with defendant, under any or all of United States patents 2,072,122, 2,087,065, and 2,214,107.

3. For an award of costs to defendant, and reasonable attorneys' fees.

4. For such other and further relief to defendant as the Court may deem proper.

PITNEY, HARDIN & WARD
Attorneys for Defendant
By FRANK C. O'BRIEN

Dated:

Of Counsel:

CHARLES H. WALKER
HENRY J. ZAFIAN
RONALD F. BALL
FISH, RICHARDSON & NEAVE
20 Exchange Place
New York 5, New York

RAYMOND J. McELHANNON
WARD, NEAL, HASELTON, ORME & McELHANNON
225 Broadway
New York 7, New York

Portions of the Transcript of Proceedings.

OPENING STATEMENT OF DEFENDANT.

[54] *Mr. Walker*: In other words, if your Honor were to take any one of these patents and just take it into a germ proof room, and read it, and not have any knowledge of what its place in the art was, you might think, as Mr. Webb would like to have you, that this is really a pretty clever mill; it is the first mill, says he, on which it was possible to roll material of such and such a character. So that if you were to fall into his little trap of thought and read the patent in that sense you might very well feel, as he would like to have you, that it isn't a difference of any substance to transfer part of the function of what was once a pinch roll having a pinch and a low lift and an upper lift position, transfer the function of the low lift to another adjacent roll. You might very well so believe, and you would be right, if it was a basic pioneer patent whose discovery and invention consisted in the idea of having a pinch roll in a pinch position, and at another time in a partially retracted position, and at still another time in a more fully retracted position.

* * * * * * *

STIPULATIONS OF COUNSEL.

[74] *Mr. Webb*: Now, your Honor, defendant has admitted in its trial brief, and we have set forth in the stipulation, which will more properly come in at the time of defendant's case that the plaintiff, Cold Metal, has the entire right, title and interest in and to each of the patents which have just been marked in evidence and of any and all rights of recovery.

Mr. Walker: Subject to correction if error be made to appear.

Stipulation of Counsel.

Mr. Webb: That is correct.

And defendant in its trial brief has admitted, and I [75] think it's agreed here, first, that Crucible installed a hot strip mill under the license agreement and placed it in commercial application on April 1, 1949.

Mr. Walker: On or about.

Mr. Webb: On or about April 1, 1949, and it is admitted and it is agreed here that on that mill and its operation under the agreement Crucible paid the royalties specified now in Paragraph 1 of the stipulation appearing as Exhibit P-1, and I think that it is also agreed here, is it not, Mr. Walker, that Crucible ceased paying royalties under the agreement on November 30, 1951.

Mr. Walker: That is my understanding that the last royalty payment tendered covered the calendar month of November, that ended November 30, 1951.

• • • • • • •

[77] It is admitted in defendant's trial brief and is agreed here, is it not, Mr. Walker, that no further royalties were paid under the agreement for the period subsequent to November 30, 1951 ?

Mr. Walker: That is right.

• • • • • • •

[78] *Mr. Webb*: And that the agreement of September 30, 1946, continued in full force and effect until April 1, 1953, at which time the agreement was canceled pursuant to the right to cancel given to Crucible by Section 11 of the agreement.

Mr. Walker: That's right.

• • • • • • •

WILLIAM B. LOCKWOOD

[223] WILLIAM BRUCE LOCKWOOD, called and sworn on behalf of the plaintiff, testified as follows:

The Clerk: May we have your full name, please, sir.

The Witness: William Bruce Lockwood.

The Clerk: Your address for the record.

The Witness: Poland, Ohio.

DIRECT EXAMINATION

By Mr. Webb:

Q. What is your age, Mr. Lockwood?

A. I am 65 years of age.

Q. By whom are you employed?

[224] A. I am employed by the Cold Metal Products Company.

Q. What is your present position?

A. I am president.

Q. How long have you been president?

A. Since January, 1946.

Q. Prior to the time that you were president, what position did you hold?

A. I was general manager prior to that time.

Q. And have you performed the duties of general manager also during the time that you have been acting as president?

A. Yes.

Q. Will you tell us briefly the business of the Cold Metal Products Company, Mr. Lockwood?

A. The Cold Metal Products Company is a producer of cold rolled strip steel, especially special qualities

of cold rolled strip steel, and also manufactures cold mills and certain auxiliary cold mill equipment.

* * * * * * *

CROSS EXAMINATION

[241] Q. Where did the Cold Metal Products Company come into the picture?

A. The Cold Metal Products Company came in in the early part of the 1940s as the operating end of the business; it was a wholly owned subsidiary of the Cold Metal Process Company, and the Products Company took care of the manufacture of the mills and of the cold roll strip business.

Q. Yes.

A. (Continuing) Which by that time had grown to substantial proportions.

Q. Yes. That left the Cold Metal Process Company, the original company, as a patent holding and licensing company and left the business of mill manufacture, demonstration and disposition of cold rolled product to the Cold Metal Products Company?

A. The Products was the operating end of the business.

* * * * * * *

[257] Q. Did you personally participate at all in the negotiations leading up to the license agreement between the parties here?

A. No.

Q. Did you participate in the sense that you sat in a capacity in which you had reported to you the results of [258] discussions and had to make decisions whether to accept or reject various proposals in regard to the agreement?

A. If there were any discussions, there were very

few, I don't recall distinctly. Mr. Webb handled that matter.

Q. I see.

A. My recollection was that—of course, we approved what Mr. Webb did, but I don't recall any discussions.

Q. Well, at that time had your company issued very many licenses under the reversing hot mill patents, you had issued several licenses at that time, had you not?

A. You are speaking of the Products Company?

Q. Either or both, the Process or Products.

A. There have been half a dozen, or more, maybe ten.

* * * * * * *

RALPH A. FREED.

[290] RALPH A. FREED, called and sworn on behalf of the plaintiff, testified as follows:

DIRECT EXAMINATION

By Mr. Webb:

* * * * * * *

Q. By whom are you employed?

A. At the present time, the Cold Metal Products Company.

Q. And what position do you hold at the present time with Cold Metal Products?

[291] A. Engineer.

Q. And how long have you been with the Cold Metal Products?

A. Well, with the Cold Metal Process, and then slid over into Cold Metal Products, it's been since May, 1930.

Q. And what has been the nature of the work, in

a general way, that you have done with Cold Metal Process and Cold Metal Products since you first went there?

A. It's been general mill engineering, primarily on hot mill work, but considerable on cold mill work, and any special equipment that was being used, or the company would want designed.

Q. General engineering work—

A. Yes, sir.

Q. —would that describe it?

A. I think so.

Q. And did you work on the initial hot mill installation which is being referred to here as being the installation at Briar Hill plant of the Youngstown Sheet & Tube Company?

A. I did.

* * * * * * *

[293] Q. I will rephrase my question. Mr. Freed, would you please tell us the general nature of the work that was done at the Briar Hill plant of the Youngstown Sheet & Tube Company in connection with reversing hot mills?

A. It was an attempt to prove out and test out a theory that had been advanced in a new method, new procedure of rolling hot strip on a single stand reversing mill by the use of pinch rolls and hot coilers on each side of the reducing mill.

Q. Were you actively engaged in that work?

A. To a quite considerable extent, yes.

Q. Was there any further work done on reversing the hot mill in the plants of Youngstown Sheet & Tube Company besides that done at the Briar Hill plant, to which you have referred?

A. Yes. After it was fairly well established that it was possible and we did roll some strip from a slab down to strip gauge, the Sheet & Tube, as well as our own company, wanted to be certain that they were able to roll from a full sized ingot direct into strip on one reversing mill. So that's the experiment they set up and worked out at the Campbell Works of the Youngstown Sheet & Tube.

Q. Are both the Briar Hill works and the Campbell Works located at Youngstown, Ohio, or in that vicinity?

A. They are, yes.

Q. You referred to Sheet & Tube in one of your last answers; is that the shorthand version of the name of the [294] company, Youngstown Sheet & Tube Company?

A. It is, it is the abbreviated form.

Q. What was the nature of the work that you did, yourself, in connection with the work done at Briar Hill and at Campbell? Tell us a little more in detail.

A. Well, the work on the Briar Hill plant consisted of two things. I did considerable of the engineering work, such as designing and changing and altering the different types of guides, did work on the pinch rolls as to change them so that they would work more satisfactorily, and it was considerable all around engineering that would be necessary in a development of that kind. Then also, on a number of their experimental and trial runs I would be out and assist Mr. Montgomery and other men there to run these tests and try out the mill and find out what the bugs were in it so that I would be in better shape to help them eliminate them the next few days afterwards.

Q. Could you give us some idea as to the percentage of the slabs which you attempted to roll on the Briar Hill installation which you actually did succeed in rolling?

A. Of course, we were depending upon the Youngstown Sheet & Tube to furnish us with the heated slabs, so when we thought we had everything lined up properly we would notify them ahead of time that we would want maybe six or eight slabs, that we figured we would be able to roll. So we would start our rolling and they would bring one down and we would attempt to roll it [295] back and forth to get it to coil. Some days maybe we wouldn't get any that would come down to what would be considered hot strip gauge, other times we would. So I would say that on an average, if we could get out of the six or eight slabs that we had ordered, if we could get one that we could roll down to a hundred-thousandth, or a little more, and get it down the table without coiling [cobbling] it, we were well satisfied, but that was about the average, one out of six or eight that we would order.

Q. What were some of the principal difficulties which you were having in connection with this work that was done at the Briar Hill plant?

A. Well, the main thing—it constituted two things, that is, both mechanical and electrical. We had some big, cumbersome pieces of machinery there, your mill, your tables, your pinch rolls and your coilers, that all have to be synchronized together so that they will all reverse in one way and then they will change directions together, and we would have quite a bit of electrical trouble in those early days as to getting those properly synchronized so they would function together

properly. It was natural if one was a little bit slower than the other and you would try to roll a strip, why you would run into a cobble, it would give you trouble. Then our pinch rolls, we had considerable trouble on them.

The Court: Tell me, what is that word?

The Witness: Pinch rolls, the pinch rolls that come [296] down and pinch it through.

The Court: Pinch rolls, yes.

A. (Continuing) We had difficulty on those because on some of the strip when the pinch rolls would come down on it it would slit, instead of pushing it on in, it would slit. So we had quite a bit of trouble on that, and some on our reels, and the side guides, I suppose we tried half a dozen different types of side guides, guiding it in before we could get something that would work satisfactorily. Now, those are just some of the things that we ran into.

Q. Were those also problems that you ran into in connection with the work at Campbell when you were trying to roll direct from an ingot?

A. Yes, primarily, but we had partially solved some of the problems out there and we gained by that knowledge, but there were others that came up, since we were starting with a much bigger ingot than we were out at Briar Hill.

Q. As I understand it, at Briar Hill you were starting with the slab and at the Campbell Works you were starting with an ingot?

A. That's right.

Q. In each instance you were trying to roll down to the finished strip?

A. That is right.

Q. Did you have difficulties in the handling of the [297] material during the carrying on of this work at Briar Hill and Campbell?

A. Oh, yes, we had considerable on that.

Q. Over what period of time did this work at Campbell and Briar Hill extend, Mr. Freed, if you can give us that?

A. I think it was some time in the middle or the late 1930s that I first started in on it, and then it was the period, I suppose, two, maybe three years.

Mr. Webb: May I have that answer read?

(Answer read by the reporter.)

The Witness: On the engineering work. It may have been a year later than that, I just don't remember. I know I had only been with the company a comparatively short time.

Q. When did you go with the company?

A. 1930.

Q. 1930?

A. Yes.

Q. I believe you said in your last answer the middle or late 1930s; did you mean the early 1930s?

A. No, I meant the middle or latter part of the year 1930.

Q. I am sorry.

A. It was the latter part, middle or latter part of the year 1930.

[298] Q. Thank you. And for how long a period did the work at Briar Hill and Campbell extend, Mr. Freed, from the time you started on it until—

A. Somewhere around three to four years.

. . . . . .

[336] Now, when we want to bring the material into the mill it is quite important that you get that in on the center of the mill, right on the path, because if it comes in a little bit crooked it will want to turn and get a camber and angle off. Then when you try to coil it in the coiling furnaces it gets a very wobbly, loose coil up there, it won't be coiled up straight. And then when you try to get it off it weaves back and forth and it gives you all kinds of trouble.

* * * * * * *

[389] Q. Would you please describe for us the functions performed by the pinch rolls of the original mill, bearing in [390] mind the three positions?

A. Of course the most important function of the pinch roll is when it is in its pinch position to perform two duties, to drop down on the strip and try to hold the end of it and retain it between the working rolls and the pinch rolls, and then as it is reversed to feed the end of this strip back in the mill. Of course the upper roll, when it is in its up position is merely to be out of the way of everything. Then at its low lift position it acts as a roller guide to the strip.

Q. Well, before going to the low lift position may I ask you whether when in the pinch position the pinch roll also performs the function of pulling the strip off the reel? That is, when you have the pinch rolls in the pinch position, do they pull this strip off the roll [reel] in feeding it back?

A. They pull the strip off the reel and feed it into the work rolls of the mill.

Q. So that in the pinch position, as I understand you testimony, the pinch rolls pull the strip off the reel and also feed it toward the mill?

A. Yes, sir.

Q. I believe you mentioned yesterday that the lower pinch roll functions, also as a table roll, is that correct?

A. It does.

[391] Q. All right. Now, in the high lift position what are the functions of the pinch rolls?

A. It is merely to be out of the way of everything so that there is free access along the table rollers to pass any material underneath that you wish.

Q. And, of course, while your upper pinch roll is in that position does your lower pinch roll serve also to carry the strip?

A. Yes, it performs that function.

Q. All right. Now let's go to the low lift position, and describe for us, please, the several functions of the pinch rolls in the low lift position.

A. When the pinch rolls are in that low lift position there are several functions that it performs. One of them is to keep the strip down fairly close to the table rollers so that it will be in and over the overhanging flanges of the side guides. Now, I think there is a drawing here that will show you the shape of those side guides.

On drawing No. 6, down in the lower righthand corner, you can see those kind of "U" shaped sections there with the opening in towards the center. Well, that is the shape of your side guides.

So you want to keep the material down close enough to the table rollers that it won't bounce up and hit that top overhanging flange on those side guides. Now, that is [392] a very important function.

Q. Would that be considered as a vertical guid-

ing action, guiding it so as to hold it in proper position in the vertical plane?

A. Yes, that could be so explained.

The Court: Just a minute, please.

The Witness: Yes, sir.

(Discussion between Court and witness, off the record.)

Q. Now, you have spoken about this function of holding the material down between the guides, this vertical guiding action. Tell us the other function, please.

A. It also has another function. Due to its frictional resistance it will maintain, or assist in maintaining the strip in the center so it won't be apt to float so much.

And then there is another—

Q. Wait just a moment. While you are on that one, just so it is clear, as I understand it, when it is in the low lift position your strip is in contact with the roll, is it?

A. Yes.

Q. And as a result of the strip passing over the roll there is friction and that prevents that strip from weaving sidewise?

A. It would assist it, yes.

[393] Q. So you have that horizontal guiding action also performed in that low lift position?

A. You see, the strip is under tension between the unwinding reel and the mill. It is coming off of this spool a little slower than the mill is taking it up. It is a very definite purpose there, so it will come off straight and won't flop over inside. So there is a little

tension in there, in between that. So this roll holding it down does have a tendency to want to keep it, due to its friction—to keep it from going sideways.

Q. Is that of any importance in preventing it from going sidewise?

A. Yes, because you want to keep it either going into the mill or into the roller as steady—so it will pile up in the center of the reel, or enter and retain its position on the center of the mill.

Q. If you don't guide it properly into the reel, do you run into any difficulties?

A. Yes, you have a lot of difficulties holding it there, and getting it off, and getting it back through the mill. It might cause a lot of trouble.

Q. If you don't have it entering into the mill properly, and have it moving sidewise, sliding sidewise, what sort of difficulties does that create?

A. It creates a very bad camber in the strip, and then [394] try to get it back in on the next pass.

Q. All right. Now, what are the additional functions, Mr. Freed?

A. There is another function it performs. The distance from the deflector roll under the furnace and the reducing rolls is quite considerable. And you get —as long as this material is flowing through they keep it as well synchronized as possible, but there is a little variation, and your strip going in at that speed will have a tendency to want to whip up and down, and by holding it down at that position it takes practically all of that whip out of the strip, so that it can be held down pretty close to your pass line, and enter your mill on a smooth, steady path instead of jumping

up and down, whipping up and down. So it also serves that function.

And then also—

Q. Before we leave that one, if you had any substantial bounce, would that give you any difficulties?

A. Oh, any time there is any bouncing or jerking you have difficulties on your rolling and on your coiling in your furnace, yes—the reels in the furnace.

Q. How about the possibility of hitting the upper portion of the guides, if you had any of that bounce?

A. Be very apt to, yes.

Q. Now, what other functions are there?

[395] A. That cylinder that operates that pinch roll also acts as a cushioning effect, so that if there is a little excess flop, or jump, or pressure up on to that, it will cushion it, so as to try to maintain your tension between the material that is being paid off of the reel and into the mill as uniform as possible.

Q. In other words, if you have that in the low lift position you have sort of a cushioning effect there and, as a consequence, it assists in giving you a uniform tension between the mill and the coiler, is that what you said?

A. That is right, yes.

Q. And what other functions are there that you recall? Have you mentioned the matter of looping?

A. No. Again, it is sometimes a little difficult to have your equipment so properly synchronized that everything will function just perfectly right, and if, by chance, when you have your reel wanting to feed the material to the mill just a little faster than it is taking it away, it gets loose and sloppy in there, and there is the danger that it might fold over, clear over,

by the time it gets up to the mill, and if you would attempt to roll it back you would have a cobble and possibly a broken roll.

But with this roll down here, a short distance away, if you do have any of these folds, it would come up against [396] that and iron those folds out, before it would get to the mill, and it would give the roller an opportunity to see that things weren't functioning just properly, and he may have to stop the mill long enough to make those adjustments.

Q. If you get one of those folds in the mill, what happens?

A. Well, it is a decided cobble. More than likely it will break your rolls.

Q. Would you describe for the Court what you mean by a cobble? That term has been used a couple of times, but I think it might be well to describe it.

A. Any time any difficulties occur in rolling where that you are unable to finish the complete rolling cycle down to gauge, or if it would go into a side guide, and dig in there, or if it would fold up, or any source of trouble where you would have to stop the material into the mill, and you couldn't go on any further, that is considered a cobble. That material has to be cut out there and thrown away. You cannot continue to roll it down to gauge, so that it is wasted.

Q. Do you have that likelihood of this looping or buckling condition that you spoke of earlier on the exit side of the mill as well as on the entry side?

A. Yes, it could happen on either side.

[397] Q. And if you had it on the exit side, what effect would your roll in the low lift position have on it?

A. Have a tendency to try to iron it out a little bit so that it could go into the coiler.

Q. It would tend to keep those loops between the low lift position and the mill so as to keep them from going into the coiler; is that what you meant?

A. Yes.

Q. Now, would you please tell us the functions of the auxiliary roll in the modified setup when it is in the low lift position?

The Court: What is that drawing over there?

The Witness: That is drawing No. 8, your Honor.

Mr. Webb: I just put it up because it shows the auxiliary roll, your Honor.

Q. Let's take a look at Drawing 20, for example, because it shows the auxiliary rolls on both sides in the low lift position.

A. Well, I would say that it performs exactly the same functions, the same purposes, as the pinch rolls in its low lift position.

Q. In other words, that auxiliary roll, when it is in the low lift position, performs exactly the same functions as the pinch roll in its low lift position?

[398] A. Yes.

Q. Is there any difference between the two setups in regard to any of these other functions that you have spoken of?

A. None that I have observed, because I have seen some very successful operations of that mill when they just had the pinch rolls, and I have seen the same very successful operations of that same mill since they have made these changes.

Q. Now, you have spoken about the auxiliary roll in the low lift position performing the same functions as the pinch roll in the original installation in its low lift position. Does it perform those functions in the same way as the pinch rolls in the original installation?

A. Yes.

* * * * * * *

CROSS EXAMINATION

[449] Q. When did you first encounter a mill, Mr. Freed, in which there was provision for lifting the pinch rolls to a low lift or a nigh lift position at the option of the operator?

A. Due to the experience we gained on the Briar Hill mill, where we only had the two positions, the up position and the pinch position, we found that dropping that a distance of eight or nine inches, something similar to that, down on the roll, that heavy weight dropping was creating quite an impact and causing considerable damages on our bearings. About that time we were working on the mill for the Dominion Foundry & Steel in Hamilton, and in that case it was a universal mill and they were going to start from ingots approximately 14 inches thick. So that meant we were going to have a drop of 16 or 18 inches, something like that. Well, that dropping that much farther led us to believe that we were going to run in a lot more damage to the equipment by [450] dropping it that far with that much weight. So we devised a method whereby we could have that pinch roll clear up out of the way during all of the slabbing operation on the ingot and everything down until it got about three-quarters of an inch or an inch thick. Then automatically the control of that was switched from the one set of cylinders over to the short stroke cylinders and then

that brought that roll down to the low lift position so it would only drop a very short distance. It gave us a little quicker operation and less damage to the equipment.

Q. The mills that you worked on prior to that time just had the pinch rolls capable of being in either the pinch position or in a position that was elevated sufficiently to let pass back and forth whatever the thickness material was that was ever rolled?

A. Well, the only mill of that sort was this experimental mill at the Briar Hill Steel.

Q. What was the situation at the Campbell Works?

A. That was the same, experimental rolling.

* * * * * * *

[483] Q. Now, I would like to understand a little more fully than I do what you mean when you say that the pinch rolls engaging the strip between the mill and the point of coiling, or uncoiling, broke up the tension. I think that was your phrase.

A. If you had a coiling reel that is overrunning, or running just a little faster than the mill, and there was nothing to interrupt it in between, it would exert uniform tension from the reel to the mill. But if in the meantime you put a pair of pinch rolls, or anything pressing down very severely on the middle of that strip between the mill and the reel you would have considerable different tension, as we noticed out there at Briar Hill, because occasionaly, if things were not being just absolutely a hundred per cent synchronized, the reel would feed off just a little faster than the mill could be taking it away, and being held there by the pinch rolls it would have a tendency to want to fold up, and

loop, and get wavy between the reel and the pinch rolls, while it would still be tight between the pinch rolls and the mill. That was one of the conditions we had to try to overcome.

* * * * * * *

[488] Q. Now, going back again to our initial situation, in which nothing touched the strip from the mill to the coiling reel, and the tension consequently was uniform throughout the length, when you put a pair of pinch rolls in contact with the strip, isn't it true that if you drove those pinch rolls with an external source of power at a speed corresponding exactly with the speed of the passing strip that they would not interfere with or break up the uniformity of tension which theretofore existed?

A. I doubt if it would be possible to set up any drive that at all times could give you that exact uniformity of motion of the roll with the strip.

Q. So that as a practical matter it would be difficult to drive the rolls at precisely the right speed, but if you did drive them at that speed then they would not interfere at all with the uniformity of tension, is that right?

A. That is just a little too technical. I wouldn't [489] want to commit myself definitely on it; no, sir.

Q. Can you think of any reason why they would disrupt the uniformity of tension if their external drive was such that they were wanting to move and being moved at precisely the speed of the strip at the point at which the rolls engaged it?

A. There is bound to be a certain amount of friction due to the compressing of that pinch roll on to the

mill [strip], a slight deformation of the strip. It might be very slight, but it would be there.

• • • • • • •

[490] Q. Now, wasn't it that interference with uniformity of tension between the mill and the winding reel which the pinch rolls caused, if they were left in engagement with the strip, that was the reason for Montgomery's desire to withdraw the pinch roll to its low lift position, and thus free the strip from that factor, tending to break up the uniformity of tension?

A. I do recall—I know of discussion on that when we were having some trouble there at Briar Hill, the overrunning of the reel, it was giving us a little trouble and a comment was made, "Well, we will have to do something in the future mills to overcome that condition." Now, that may have been the outcome of his desire then to raise that roll.

• • • • • • •

[513] Q. "In accordance with the present invention, however, I utilize the pinch rolls only while starting the leading end of the breakdown ough the mill and into the coiling reel on the opposite side, the pinch rolls being thereafter retracted, freeing the strip between the mill and the reel."

Don't you understand that the same as I do to mean that the pinch roll is retracted until such a point as to be out of contact with the strip?

A. No, sir. I would interpret that that it is freeing it from that pinching action so that the strip would be free to float clear from the mill to the reel.

Q. Well, I invite you to call our attention to anything in the text of either this, or any of the other Montgomery patents, to support your position.

A. I am merely putting my own interpretation, as I see it as an engineer. That is all I can do.

Q. Wasn't it your understanding that Montgomery's—an important purpose he had in retracting that pinch roll, so as to free the strip between the mill and the reel, was to prevent the pinch roll from having such a contact with the strip as to interfere with the uniformity of tension which would otherwise exist between the coiler and the mill?

[514] A. Of course, I have no way of knowing what Mr. Montgomery had in his mind, but I would say that that would be one of the functions of raising it, to eliminate some of that trouble that we had on the original mill, by the loose folding, loose, floppy coils, between the reel and the pinch rolls.

Q. Would you mind taking a look at page 4 of this Patent 107, Column 2, line 43, where it says—

A. What line, please?

Q. Page 4, Column 2, line 43. "The pinch roll 88 on that side is thus lifted from the material." Now, with that additional light on the question of what Montgomery's purpose or intention and operations were, isn't it clear to you that it was his purpose and intent to withdraw that pinch roll to such a point that it was no longer in contact with the material?

A. I wouldn't put that interpretation on it; no, sir.

Q. Then a little further down in that column, line 56, where it says, "The cylinders 82 on the exit side of the mill thus operate to raise the associated pinch roll from the strip." Doesn't that give you the idea that he intended to have the pinch roll removed from physical contact with the strip?

A. No, I don't, because he certainly would know that it would have to be raised more than an inch and a half [515] to free it so that it would have no frictional contact with the strip whatsoever.

Q. And then the next sentence, "The strip is thus free between the winding and unwinding coilers except where engaged by the mill." Doesn't that give you the idea that the strip is not to be in contact with this pinch roll after its retraction.

A. I would say that it would be free from any pinching action and not physical contact.

* * * * * * *

DR. GEORGE SACHS.

[557] GEORGE SACHS, called and sworn on behalf of the plaintiff, testified as follows:

The Clerk: May we have your full name, please, sir?

The Witness: George Sachs, S-A-C-H-S.

The Clerk: And your address for the record?

The Witness: 103 Bradford Lane, Syracuse, New York.

DIRECT EXAMINATION.

By Mr. Webb:

Q. Doctor, will you please state your age?

A. I am 60 years old.

Q. And are you connected with Syracuse University at the present time?

A. That is correct.

Q. What is your connection with the university?

A. I am Associate Director of Syracuse University Research Institute and Professor of Metallurgy.

* * * * * * *

[565] Q. Doctor, are you familiar with the Crucible hot strip mill, which is in issue here?

A. Yes, I have seen that mill twice.

Q. And was it in operation when you saw it?

A. Yes, it was both times in operation.

Q. And have you inspected and studied operations on similar reversing hot strip mills?

A. I have seen two more reversing hot strip mills in Germany, a mill at the plant of Hoesch, and another very modern mill at a plant of Capito & Klein, which is a Krupp concern.

Q. And have you studied the drawings of Crucible's mill, both the original and the modified mill, which constitute Exhibit P-16, these large drawings?

[566] A. Yes.

Q. Well, referring to the original mill, doctor, and particularly to the pinch roll setup, would you please state some of the functions performed by the pinch rolls in the different positions they occupy?

A. Well, the pinch roll in this mill is not a conventional or simple pinch roll as the term was usually applied in the previous days; it is a much more complicated piece of equipment which has also considerably more function.

Originally the pinch roll was just used in the pinching position for supplying material to some other piece of equipment. There are many such applications, including this rolling mill application.

Now, the new pinch roll has a number of additional functions, which are illustrated or which are effected by what is called the three different positions; namely, the pinch position, the low lift position and the high lift position of this roll.

In addition, the lower pinch roll, as such, is a table roll, or vice versa, a table roll is utilized as the lower pinch roll, and has also all the functions which a table roll in a rolling mill has. It works in synchronized fashion with all the other table rolls—the lower pinch roll.

[567] Shall I continue to describe those functions?

[568] Q. Yes. Will you please, Doctor, go ahead?

A. Now, in the pinch position the pinch roll also has some additional functions. The actual pinch function is a feeding function and in this case the pinch roll feeds the strip from its position into the mill and then the mill takes over the feeding part. But at the same time the feeding function is associated with peeling off the strip from the coiler. The coiler is, well, if the coiler would be running by itself there would not be a synchronized delivery of the strip to the mill. Furthermore, as far as I can judge, the pinch roll has a definite function of stopping the strip when the rolling process is being terminated and the mill and the coiler are being stopped. Due to the setup there is a certain danger that the strip may run over the stop position and may run out of the pinch roll and in order to avoid this the pinch roll is immediately lowered at the same time or immediately after the mill and the coiler are stopped and grips the end of the strip, trailing end of the strip and it stops that trailing end of the strip in its stopping position.

Now, the low lift position in the first place acts as a guide. This guiding function is a somewhat complex function; it limits the possibility of the strip to be raised above a certain point and thus it keeps the strip down between the side guides. It also has, under those condi-

tions, frictional contact with the strip, which helps to prevent the [569] strip of cambering or running sidewise. It also prevents the strip, which has in particular at the beginning of the rolling process a certain irregular —tendency to run irregular, and what we call to loop up, to form a sort of a loop, sort of a fold, it prevents that this fold be caught between the rolling mill and the pinch rolls and thus gives the coiler a better chance to pick up this loose material and to run up to full action. Furthermore—

Q. May I interrupt just a moment there, Doctor. In regard to the last function of preventing that looping on the exit side, if I understood your testimony, that is where the strip is coming through the mill and going to the coiler, the pinch roll in the low lift position prevents those loops from getting over to the coiler and causing irregular winding? Is that what you had in mind?

A. Well, the trouble I have seen to some extent looping is also between the rolling mill and the pinch rolls; it has a tendency to, yes, to run up into the coiler and cause poor coiling.

Q. So with that pinch roll in the low lift position that would keep the looping away from the coiling mechanism?

A. That is correct, yes.

Q. And on the other side does the pinch roll in low lift position have any effect, also, so far as that looping is concerned?

[570] A. It also helps to keep the looping down or keep the strip down. It prevents the looping from becoming dangerous.

Q. Well, does it have any tendency at all to keep the loops which might form between the coiler and the

pinch rolls away from the mill from folding over and going into the mill?

A. That is correct, that is the most dangerous effect of looping, that the strip may double up and cause difficulty.

Q. All right. Excuse my interruption, Doctor, and go ahead with your description.

A. So this is what I might call the guiding function of the low lift position. Now, the low lift position also has a certain function in tensioning the strip. It does not affect the tension as such; the tension as such is caused by the difference in speed between the mill and the coiler. What it does is, if there is some lack of synchronizing in this respect, that the pinch roll acts as a buffer and helps somewhat to equalize that tension. In addition, the pinch roll in the low lift position has a third function, and that is it keeps the strip away from the table rolls and the table aprons and thus eliminates some scratching of the strip and since, of course, this is expensive material, like stainless steel, any damage to the surface of the material is a disadvantage.

Q. Now, Doctor, I wish you would refer to the so-called modified mill and the pinch roll arrangement, the pinch roll [571] setup, and tell us what the functions are which are performed by the pinch rolls in that setup.

A. In the modified mill the pinch roll apparatus is more complicated. A third roll has been added to it and this roll has taken over the function of the low lift position so, in my opinion, this piece of apparatus by substantially the same means, performs exactly the same functions and leads to exactly the same result as the original pinch setup, which consisted of two rolls which could be lifted to a low lift position and to a high

lift position. As I said already, or mentioned already, but to make it more clear, is that now the two pinch rolls only exist in either the pinch position or the high lift position, while an additional roll is added which is lowered or raised to be in the low lift position, and both rolls together are raised to be in the high lift position.

Q. From the standpoint of the operation of the mill is there any difference between the old and the new setup?

A. There is no difference whatsoever.

* * * * * * *

[576] Q. The claim then specifies "freeing that portion of the breakdown between the mill and the point of coiling, and tensioning such portion uniformly throughout." Will you explain the meaning of those expressions and tell us whether they apply to the Crucible modified mill, and how?

A. The freeing obviously relates to the change from the pinch position to the low lift position. Now, in the pinch position the rolls are able to provide a considerable force to the strip and thus cause the tension on one side of the pinch rolls to be considerably different from that on the other side of the pinch rolls.

[577] However, when the pinch rolls are raised to the low lift position then the strip is only very superficially in contact with both the upper pinch roll and with the deflector roll in the furnace. But this contact is not sufficient to set up any substantial difference between the tensions on one side of each roll and on the other side of each roll. So substantially there is a uniform tension under those circumstances, the same way as there is a uniform tension in a strip, or in a cord as you pull it over a pulley.

* * * * * * *

WILLIAM H. COLVIN.

[634] WILLIAM H. COLVIN, called and sworn on behalf of the defendant, testified as follows:

The Clerk: What is your address, for the record?

The Witness: Box 2435, Route 5, Sarasota, Florida.

DIRECT EXAMINATION.

By Mr. Walker:

Q. Have you presently any connection with the defendant, Crucible Steel Company, Mr. Colvin?

A. I am a member of the board of directors.

Q. How long have you been a member of the board?

A. Since February 14, 1945.

Q. Have you at any time served the company in any other capacity?

A. On that same date I was elected president.

Q. And served as president at Crucible for how long?

A. Until May 31, 1954.

Q. Had you had any previous experience in this steel rolling business?

* * * * * * *

[635] Q. What was the situation that led Crucible to install that mill?

A. I cannot answer that too briefly, Mr. Walker. The company was—

Q. I don't want a long extended answer, Mr. Colvin. Perhaps I can ask you a more specific question and get the part of it that is really pertinent here. Was this mill installed to roll any particular type of product?

A. We had two finishing departments which this mill could be tributory to, one in agriculture implements and one in cold finished stainless steel.

[636] Q. What kind--

A. (Continuing) We thought we could expand them once we had the missing link of hot roll strip.

Q. Was hot roll strip the stocking starting material desired by the company for the production of these agricultural products?

A. Yes, sir, Crucible was well equipped to make iron and make steel, break the steel ingots down into slabs. It was not equipped to take those slabs from there into hot roll strip in coils.

Q. Hot roll strip in coils was desired for the agricultural products?

A. In coils, and in that case, in agriculture, also in straight flat material.

* * * * * * *

[639] Q. With what other type of mill were you familiar which was suitable for rolling hot steel strip coils at the time you were giving consideration to this new mill for Crucible?

A. The only other mill different from these with which I was then familiar was the Steckel type mill at McLouth Steel in Detroit, with which I was very familiar.

Q. Was that the mill that McLouth had at their Livernois Avenue plant?

A. At their Livernois Avenue plant, yes.

Q. You say you were very familiar with that?

A. Yes, I was.

Q. How did it come about that you were very familiar with that?

A. Mr. McLouth was one of my personal and most intimate friends I had in Detroit. We had a cold roll strip finishing mill at Rotary Electric for which we bought hot roll strip, such as would come off the McLouth type of mill, or a continuous mill, and we were substantial customers of McLouth Steel. He had a very great financial difficulty at the start of his career and we were interested and helpful in trying to keep him going to have a local source.

[640] Q. Were you, in view of that customer relationship you had to McLouth, in and around that Livernois mill from time to time?

A. Yes, sir.

Q. You saw it in operation?

A. Yes, sir.

Q. Now, what factors led you to choose the reversing hot mill for Crucible as distinguished from the continuous mill which you said was the other type available for producing that hot roll product?

A. Anyone who had the capacity would prefer the continuous, of course. There were two overwhelming reasons in our case, one was the fact that our total company does not produce—then or now—an amount of steel, if devoted solely to that purpose, which would supply an adequate operation on a continuous mill. A continuous mill of the width that we would need to cover the range of our products would probably have a monthly capacity substantially in excess of 150,000 finished tons a month. We can manufacture in the neighborhood of 90,000 tons in the ingots, from which something like a 70 per cent yield would come out in the finished product. And we have a substantial business in bars, rods, wire and other products, from which we did

not want to divorce ourselves and concentrate solely on strip; even if we had, we would [641] even then not been able to have used the continuous mill more than 45 per cent of its possibilities. And in that case the resulting cost relates almost directly to the rate at which you operate.

The second reason, and one which was of extreme importance, is the relative cost of the two projects. The cost of the continuous mill as of the time that I went to Crucible and had completed the study and was ready for a recommendation would be in the area of thirty-five to forty million dollars for the hot mill alone. That was wholly beyond the capacity. Our company represents between 8 and 9/10 of one percent of the steel industry. It is a specialty steel company and not a carbon volume tonnage producer.

Q. What was the approximate cost of the reversing hot mill that you did install as compared with that thirty-five to forty million dollar cost of a continuous mill?

A. The estimated cost of the installation, both hot and cold, as of the summer of 1946, before OPS went out, was twelve and a half million dollars. And I believe that what was roughly divided half and half between hot and cold, or in the neighborhood of six million for each to six and a half million for the hot mill and perhaps the same amount for the cold mill installation. We were not able to install it for that.

[642] Q. I take it from your reference to OPS that the actuality turned out to exceed the estimate?

A. Violently; yes, sir.

Q. What was the fact about that?

A. It violently exceeded it. The actual figures

were about $19 million to get what we had started out to get for $12½ million.

Q. Is there some figure that is taken as a rule of thumb as representing the cost per day of having a continuous mill set idle?

A. That figure, of course, changes with every pay raise, and every tax increase, and the cost of money, and so on. As of the time we are now talking, my recollection is that it was calculated to represent a cost of $10,000 a day not to run the mill.

Q. So I take it you didn't debate very long between the continuous mill and the reversing hot mill, once you had surveyed the field?

A. No, sir; not as between those two factors. As to what kind of a reversing hot mill, of course, we did give that all kinds of thought.

* * * * * * *

[664] CROSS EXAMINATION.

By Mr. Webb:

Q. Mr. Colvin, where did Crucible get its hot strip prior to installing the mill, that is, the reversing hot strip mill?

A. We bought some hot strip, as such, and we supplemented that by the melting of steel and rolling slabs of our own manufacture, shipping those, I believe, to two mills, who rolled them to hot roll strip for us and shipped them back; one of which was Allegheny Ludlum, and I believe the other was Butler.

Q. And you put in the reversing type of hot strip mill that you did put in because your operation couldn't afford a continuous mill, is that correct?

A. That is one of the two reasons, yes.

Q. And Crucible couldn't afford a continuous mill?

A. Very definitely we couldn't afford it, no, sir, nowheres near.

Q. This small reversing hot mill has admirably served the purposes of Crucible since it was put in, has it not, in so far as supplying to Crucible hot roll strip for its agricultural department and for its cold rolling department?

A. It has supplied it as well as a compromise mill could, and we have not been disappointed in the mill, if that is what you mean.

* * * * * * *

[666] Q. One of the advantages of this particular type of mill for an operation such as Crucible has is its extreme flexibility in so far as rolling small orders of a wide variety of products is concerned?

A. Very definitely.

Q. And another advantage of this particular type of [667] mill is that you can provide a product that has excellent edge characteristics, is that not correct, by reason of the fact that you can keep heat in the edge portions of the strip during the rolling?

A. That is my belief. I don't want to qualify myself as one that is thoroughly familiar with that very complex problem. That is my belief, with particular reference to stainless.

* * * * * * *

LEROY VALETTE.

[698] LEROY VALETTE, called and sworn on behalf of the defendant, testified as follows:

The Clerk: May we have your full name, please, sir?

The Witness: Leroy Valette.

The Clerk: Your address for the record?

The Witness: 12 Oak Ridge Road, Pittsburgh 29, Pennsylvania.

DIRECT EXAMINATION.

By Mr. Walker:

Q. Mr. Valette, were you at one time employed by Crucible in connection with its reversing hot strip mill?

A. Yes, sir.

* * * * * * *

[768] Q. And would the presence of those pinch rolls have any material effect, in your opinion, upon the uniformity of tension between the winding reel in the mill and between the mill and the unwinding reel?

[769] A. As against Steckel—an arrangement such as Steckel '670, I would say yes. The winding reel is supplying the force, for example, for the tension, but between the winding reel and the mill there is a pair of idler driven rolls, which are being turned by the winding reel, or the movement of the strip, due to the winding reel.

* * * * * * *

[782] Q. Do you consider it feasible to operate one of these reversing hot coiling mills without having tension on the strip, on both the delivered strip and the entering strip?

A. I can't visualize it being operated at all, from our own experience.

Q. What has your experience been in that regard?

A. That any time that there is a failure of tension on one reel or the other, as has been said by other witnesses, the material will flop from one side to the other; in other words, it will skid and do such things as that.

Q. Get into a sort of a mess?

A. That's right. In other words, the steel is coming to the winding reel faster than it can take it, so it has no set place to go to. On the unwinding reel, the same thing will apply. If it is unwinding faster than the mill is receiving it, it takes the shape somewhat of a clock spring that has been let loose.

* * * * * * *

[788] CROSS EXAMINATION.

By Mr. Webb:

Q. Mr. Valette, you spoke this morning about the Cushwa patent. You heard Mr. Colvin's testimony yesterday, didn't you?

A. Yes.

Q. And Cushwa shows the type of mill which Mr. Colvin said Crucible could not use, does it not?

A. That is right.

* * * * * * *

[811] Q. Now I would like to refer to some of the advantages that are specified on page 2 of the patent. Patent '065, and let's see whether or not Crucible doesn't in its modified mill get those advantages that are specified there. Montgomery states that a higher finish can be obtained than by using the 4-high mill for

both slabbing and coiling operations. That is correct, isn't it?

A. No, the finish is a function of how well you keep the finish on the rolls you are working on. What does happen, if [812] you are using two stands, you will change fewer rolls in the one stand and maintain a finish longer than you would if you were using that same mill to breakdown from four or five inches.

Q. And Crucible gains that advantage that is expressly stated there in the '065 patent, does it not, in its modified mill?

A. We divide our work.

Q. Yes. In answer to my question, it is true, isn't it, that Crucible gains that advantage that is stated there?

Mr. Walker: Just a moment. What advantage? You talked about finer finish and the witness answered you about frequency of roll changes; now, which one are you talking about?

The Court: Let's see, in the first place a higher finish can be obtained by using the 4-high mill for both slabbing and coiling operations?

Mr. Webb: "Than by."

The Court: "Than by"?

Mr. Webb: Yes, that is what it says.

Does your Honor understand that? I will develop it a little further.

(Discussion off the record.)

By Mr. Webb:

Q. It is true, isn't it, Mr. Valette, that by virtue [813] of the fact that Crucible uses the two stand in-

stallation, namely, the roughing mill and the 4-high reversing, or finishing mill, it gets a higher finish on its product than it would obtain if it did all of the operations, that is, both the slabbing and the coiling operations on the same mill?

A. As previously stated, Mr. Webb—

The Court: Well, is it true or isn't it true, or is it subject to explanation?

The Witness: Well, there is a qualification to it. It is just a question of how long you retain that finish. Now, if you do it all in one mill you will change that mill oftener to retain a given state of finish; by dividing it between two stands you will find it a little—that this set of rolls will retain that higher finish for a longer period of time. So that particular roll wouldn't be changed as often. But as far as a higher finish is concerned, the finish that you will put on it is pretty much governed by the finish that is put on in the first place and then how long it takes to become unsatisfactory.

Q. Now, this next advantage is that since the slabbing operation is confined to the Universal mill, by far the greatest portion of free scaling has occurred before the material reaches the 4-high mill, at which time it is characterized by a tight, thin layer of oxide which adheres to the strip throughout the further rolling.

[814] We have talked about that matter of free scaling so I won't need to go over that again, but I do want to ask you one question, and that is that it is true, isn't it, that the strip in the modified Crucible mill is charac-

terized by a tight thin layer of oxide which adheres to the strip throughout the further rolling?

A. Yes, we do no scaling during the rolling operation at the 4-high mill—after it has reached the 4-high mill.

Q. And the patent also states that "the output of the 4-high mill is increased from 25 to 30 per cent, furthermore, because of the fact that it is operating at high speeds a greater portion of the time than when slabbing operations are affected therein." Now as I understand that, that means that where you are doing part of the work on the one mill, doing your slabbing operations on the one millstand and doing the remainder of the work on the 4-high reversing mill, the 4-high reversing mill is able to operate at a nigher rate of speed for a greater portion of the time, and therefore the total output of the mill is increased. Is that your understanding of that?

A. Yes. It is my understanding that since another mill is doing a part of the work the work load on this mill is reduced and consequently the time for producing a finished product, rather than part of it being used for intermediate work, it does permit it to produce more, that is true.

[815] Q. Yes. And that is true with regard to Crucible's modified mill?

A. That's right.

Q. Then going down, commencing with about line 30 of that same page of the patent, the patent states: "The reduction in the wear on the rolls of the 4-high mill makes it unnecessary to change rolls as frequently as has heretofore been the case." That applies to the Crucible mill, modified mill, does it not?

A. I would like to answer it this way: that the number of roll changes in the Crucible mill—the roll changes will be more frequent per ton of output if we did all the work on one stand.

Q. All right. Then the patent mentions this matter of shearing, which you discussed, stating, "The shearing of the ends of the partly reduced slab before rolling greatly facilitates the entry of the material into the furnace reels, making the operation of the mill 15 more efficient and avoiding the delays and loss of material incident to repeated efforts to cause the end of the piece to engage the reel."

A. That is the purpose for which we shear the ends.

* * * * * * *

[830] Q. No, I realize what you said, Mr. Valette. What you, in effect, said was that there is nothing about the construction to prevent—

A. That's right.

Q. —the operator from doing this. But, of course, that doesn't advance anything at all. The fact is that Steckel teaches keeping the pinch rolls down, does he not?

A. My understanding of the patent is that he did disclose that.

* * * * * * *

[870] Q. Now referring to the Keeney & Ferm patent, which you talked about when you were discussing this '122 patent yesterday, Mr. Valette, I would like for you to tell us if it is not true that the pinch rolls in Keeney & Ferm are used only for feeding the strip to and from the mill and the coilers?

A. The pinch rolls in the Keeney & Ferm patent are used for feeding the end into the mill from the opposite side, feeding the material into the coiler, and when engaged they are disconnected from their drive and then act as idle rolls.

Q. Well, those feeding operations are the only functions performed by those pinch rolls in the Keeney & Ferm patent, is that correct?

A. Well, the Keeney & Ferm—

The Court: Well, is it correct or isn't it correct, or can't it be answered?

A. Well, as a function, yes, except that they do somewhat [871] the same thing as this roll, deflector roll here.

Q. Well, I didn't ask you about the deflector roll in the Crucible mill.

A. All right.

Q. I was asking you about the pinch rolls with Keeney & Ferm. The answer to my question is yes?

A. Yes.

Q. All right. In the Keeney & Ferm patent there is only one position for the pinch rolls, is that not correct?

A. Yes; they do not disclose raising or lowering.

Q. Yes, they stay in that one position at all times, there is no high lift or low lift position?

A. That is right.

* * * * * * *

[896] Q. Mr. Valette, will you please turn to page 6 of patent '107, and refer particularly to Column 1, commencing at line 8. That states there, "By tensioning the portion of the breakdown between the mill and the coiling reel, I cause the material to coil tightly and

accurately on the coiling reel, thus avoiding skidding and possible deformation of the edge of the breakdown on the next pass."

That is done and that advantage realized in the Crucible modified mill, is that correct?

A. Yes, we tension it between the mill and the breakdown.

Q. And the answer to my question is yes?

A. Yes.

Q. The specification then proceeds, "The tension also serves to remove any camber which might be rolled into the strip by the mill."

The tension on your Crucible modified mill functions in that way, does it not?

A. Can I make a slight reservation, in that tension will sometimes remove camber and sometimes won't, depending on the thickness and various other factors.

[897] Q. Generally speaking, however, where tension would be capable of removing the camber in the Crucible modified mill, the tension which is employed serves that purpose?

A. Yes.

* * * * * * *

DR. GEORGE SACHS.

DIRECT EXAMINATION.

By Mr. Webb:

[933] Q. Did you on your visits to the Crucible hot strip mill during 1955 observe the so-called hold-down or auxiliary roll in operation?

A. Yes.

Q. What were your observations as to the operation of that roll and the conclusions you drew?

A. I noticed that the hold-down roll was going up and down by somewhere between a half inch and one inch—this of course is a guess—repeatedly during the operation of the mill.

Q. What conclusion did you draw, Doctor?

A. From this observation I drew the conclusion that the hold-down roll assisted in tensioning the strip. Now, in order to explain how I arrived at my conclusion I would [934] like to mention, or I would like to say that when a strip is under tension as it runs over a roll with a certain angle, it exerts a considerable force on that roll. Now, if that roll is backed up elastically, as it is in the case of either hydraulic or pneumatic pressure, then the tension of the strip—variations in the tension of the strip will reflect themselves in movements, up and down movements, of that roll. Certain variations, not all variations will reflect. At the same time, if the roll goes say up, it means that the tension in the strip has a tendency to increase. However, if the roll goes up, the pass of the strip becomes shorter and this in turn reduces, again, the tension, so there is a certain counterplay between the hold-down roll and the tension in the strip. This play is in that respect that the roll helps to keep the tension in the strip more uniformly than it would if that roll would be rigid or wasn't there at all.

* * * * * * *

[940] Q. Now, doctor, do you have the Montgomery '107 patent there before you?

A. Yes.

Q. Referring to the structure disclosed, and the operation described in patent '107, in regard to the tensioning of the strip, would you please tell us whether the apparatus and the method described there neces-

sarily provide uniform tension between the mill and the points of coiling?

A. Yes, as far as I can understand this claim, freeing of the portion of the breakdown between the mill and the point of coiling necessarily provides tensioning of this portion of the strip uniformly throughout.

Q. Now, that is not exactly what I had in mind, doctor. In the patent there is a description of the tensioning of the strip, and there is the apparatus that is disclosed in the drawing, and my question is merely [941] whether, if you utilize the apparatus and follow the teaching of the patent in regard to tension, do you necessarily obtain the uniform tension between the point of coiling and the mill?

A. Yes, I do.

Q. Now, doctor, at pages 767 and 768 of the record Mr. Valette testified about the tension apparatus and the so-called tension disclosure of the Keeney & Ferm patent. Now, I wonder if you will tell us what the correct situation is regarding tension on the strip, on the winding or exit side of the Keeney & Ferm mill?

A. The apparatus disclosed in the Keeney & Ferm patent has not the ability to retain or to keep the tension constant if there is no synchronization between the mill and the coiler. The only function which this apparatus has is to take up the loop and to prevent the loop of folding over on itself. But it has no effect on synchronizing and therefore no effect on the tension.

It can be also shown—I could demonstrate it, if necessary—that once the tension is relieved, once—the tension which is being set up by this looping arrangement is insignificant compared to the tension which is necessary to hold that looping arrangement down in its

normal position where it is practically flat, where the rolls are all in one line.

[942] Q. So that your conclusion is what, as regards the tension on the strip in that Keeney & Ferm patent?

A. That device is completely inoperative as far as maintaining tension in the strip is concerned, and only operative as far as keeping the loop under control or out of the way where it could do some damage.

Q. Now, Doctor, does that Keeney & Ferm patent disclose any structure providing for uniform tension on the exit side?

A. I have to look up that patent again.

Q. Well, I think you may have already answered what I have in mind in that particular question, Doctor. I was just more or less summarizing what you had previously said on that subject. Let me modify my question to state it in this way: As I understand what you have stated, the patent does not disclose a structure on the exit side for providing uniform tension in the strip, is that right?

A. That is correct, yes, with the emphasis on uniform.

Q. Yes. Now, in that same Keeney & Ferm patent you find a band brake for the avowed purpose of putting tension on the strip as it goes into the mill. What can you say as to the effectiveness of a band brake such as that disclosed in the Keeney & Ferm patent for putting tension on the strip?

A. Well, the band brake is a poor means of applying tension; [943] primarily for two reasons: the one is that today band brakes are known to be very inconsistent and they don't last very long, and during the life of the brake the tension changes considerably—changes con-

siderably. In addition, a band brake is a means of applying a constant torque, or intended to apply a constant torque on a coiler. However, as the coil keeps on growing when the strip is wrapped around the coil, in order to get a uniform tension in the strip the torque would have to increase in proportion to the diameter of the coil, and the band brake, of course, cannot be adjusted or cannot allow to provide or to supply this necessary increase in torque with increase in the diameter of the coil.

Q. You spoke, Doctor, about the increase in the coil size. We are talking about the entry side of the mill. Does that same situation prevail in the reverse, where the coil side is going down?

A. Yes; I made a mistake, I should have said the coil is decreasing in size and the torque has to decrease to provide a constant or uniform tension, and the band brake is not in a position to provide this function.

Q. Now, Doctor, will you please tell us the relationship between the speed of the strip as it leaves a pair of reducing rolls and the speed of the rolls themselves, and if you care in your explanation, you may bring in the [944] entering speed of the strip so as to complete the picture. But I am particularly interested in the relationship between the speed of the strip as it goes out of the mill and the speed of the reducing rolls.

A. Well, I assume it is quite clear that the speed of the strip on the entry side is much less than on the exit side.

Q. Well, is that necessarily so when you are reducing metal?

A. That is necessarily so because I have to pass the same volume through in front as I have in back, and

as the strip is thinner in front than in back it has to run faster to make up the same volume in the unit of time. Now, that means automatically that the roll, the speed of the surface roll has to be somewhere between those two speeds because otherwise it would not supply or feed, as we say, the strip through the mill. So the speed of the roll is between the exit speed and the entry speed. Now, what is actually the surprising and somewhat difficult point to explain is that it is much closer to the exit speed than to the entry speed. Offhand, one would imagine that it would be halfway between the two speeds, but there are two reasons for that, which I may explain in using Exhibit No. D-1-A.

Q. Fig. 1.

A. I am showing, or I am pointing to the curved contact [945] surface, the curved line just over the lower roll, just above the lower roll. This is the contact surface, or line in this case, between the strip and the roll. Now, if I had a pressure about halfway on that curved line acting on the roll, which we call the resultant pressure, this would be the point where the strip and the roll run at the same speed. And left of this line the strip would run faster and right of this line the strip would run slower. In other words, what happens is that roll pushes the strip together, it squeezes metal out, back and forth, and these are superimposed to the uniform movement of the strip.

Now, you can see, or one can see that the thickness of the strip at this halfway point is on a curved line much closer to the thickness in front than to the thickness in back. In fact, what that means, if you would assume that the pressure was halfway on that contact area, that the difference in speed between front and roll

would be about a quarter or a third of the difference in speed in back. So say we have a reduction of the 25 per cent, then the strip would run in front maybe five or six per cent faster than the roll, and in back of the roll 17, 18 per cent slower than the roll.

Now, actually what we call the no slip point, the point where the roll and the strip run at the same speed [946] is actually, usually, much closer to the front, to the exit of the strip than to the back. That accounts for the fact that then the strip at the exit runs only a few per cent instead of six per cent, say only two or three per cent faster than the roll.

Q. And is that the order of magnitude of that difference in speed, Doctor?

A. Well, as I say, under normal condition it may be two or three per cent, or may be even less; under certain abnormal conditions it may be as much as 10 or 15 per cent faster than the roll.

Q. Now, Doctor, at pages 777 to about 779 of the record Mr. Valette testified regarding preventing looping, and he testified that the pinch rolls do not have any effect on preventing looping. Would you please tell us what the situation is in regard to the pinch roll in its low lift position in the Crucible mill and in regard to the auxiliary or hold-down roll in the Crucible mill so far as preventing looping from forming, or whether they have any effect at all in the event that loops do form as a result of some condition in the mill?

A. Well, neither the pinch roll in the low lift position nor the hold-down roll in the lower position prevents looping. As I expressed before, the looping is simply and singly the function of the relative speeds of roll, [947] coiler and uncoiler. However, if there is some looping

then the pinch roll in the low lift position and the hold-down roll in its lower position, have a certain function, and that is that they can keep the loop away from the mill and, therefore, avoid that any loop will fold over and be rolled over by the mill. In other words, they exert a certain control about the position of the loop, and in that respect avoid serious damage due to looping. They won't eliminate it. If the looping is bad there is nothing which can help it.

Q. In other words, the pinch roll in low lift position and the auxiliary roll in low lift position do not prevent the looping, but they do prevent the loops which do form from interfering with the proper operation of the mill?

A. That is correct.

* * * * * * *

RALPH A. FREED.

DIRECT EXAMINATION.

By Mr. Webb:

[969] Q. Where did you first install pinch rolls with the high lift-low lift position?

A. Well, I have testified to that before, but it was either [970] the Dominion mill or the McLouth mill, because they were both going through practically at the same time.

Q. Well, did the installation of those pinch rolls accomplish what Mr. Montgomery had in mind, as you described it?

A. Yes, it certainly assisted in helping us from damaging that equipment. We had no further trouble from that end, but we also, as I have testified before, to our great surprise, we had a lot of other functions come

up that assisted us in our operation of that mill that made it really possible. I have gone into that before so I don't think it is necessary to enumerate those all again.

Q. You say you were surprised, is that the word you used?

A. Yes, because we hadn't anticipated those things.

Q. You are referring to the functions which you described in your testimony earlier?

A. That is right.

Q. Yes. Did those functions materially assist in solving any problems relating to the feeding of the strip?

A. A lot of the difficulties that we had previous to that time were more or less eliminated or decreased in effect.

* * * * * * *

[971] Q. Are you familiar with band brakes of the character described in the Keeney & Ferm patent for braking the unwinding reel?

A. I am, yes.

Q. What has been your experience to the effectiveness of such a brake that provides uniform tension on the strip?

A. Well, primarily the usage of a band brake, in most all instances, is to stop a rotating body. If something is rolling, your brake is here, it clamps onto it and stops it. But as far as any type of brake of that kind to maintain a constant tension throughout its life, or a long period of time, you run into this difficulty: You have generally a metal disk and friction material called the brake band that come together. This brake band is of such a nature that it will, under high speed and

usage, will have a tendency to glaze over, just like your old brake bands used to in automobiles, so after they got so old they would slide and wouldn't hold. Well, you had that effect and therefore when it would slide your tension would be entirely different. And another thing, it wears, it gets down thinner and you have to replace your band occasionally. All right, it would require constant adjustment to take advantage of that wear. So those two [972] things would make it practically impractical from an operating standpoint to be able to have that type of a brake that would maintain any constant tension over any period of time.

Q. Would such a brake operate in such a way as to compensate for change in the diameter of the coil of strip as it is being unwound?

A. No, I think Dr. Sachs covered that, that it doesn't take into any effect of the various size of the coil, either increasing or decreasing.

Q. Does that have an effect on uniformity of tension?

A. It would, because you have your torque arm that you are operating through.

* * * * * * *

Plaintiff's Exhibit P-2.

Plaintiff's Exhibits.

EXHIBIT P-2—Agreement Between Cold Metal and Crucible, Dated September 30, 1946.

AGREEMENT

THIS AGREEMENT made the 30th day of September, 1946, by and between THE COLD METAL PRODUCTS COMPANY, a corporation of Ohio, having a place of business at Youngstown, Ohio, (hereinafter referred to as "COLD METAL"), party of the first part, and CRUCIBLE STEEL COMPANY OF AMERICA, a corporation of New Jersey, having a place of business at New York, New York, (hereinafter refererd to as "CRUCIBLE"), party of the second part,

WITNESSETH:

WHEREAS:

A. COLD METAL warrants and represents that it is the owner of the following United States Letters Patent:

Patent Nos.:	1,857,670	2,087,065
	1,918,968	2,116,121
	1,977,214	2,214,107
	2,072,121	2,219,150
	2,072,122	

and that it has the right to grant thereunder the license herein set forth.

These patents and any patents covering improvements thereon which COLD METAL may now own or may hereafter own or acquire are hereinafter collectively referred to as the "Cold Metal patents."

Plaintiff's Exhibit P-2.

B. CRUCIBLE desires to acquire and COLD METAL desires to grant the hereinafter defined licenses under said Cold Metal patents.

NOW, THEREFORE, in consideration of the mutual promises hereinafter set forth, each party executing this agreement with the intention of being legally bound hereby, it is agreed as follows:

SECTION I

1.

The term "simple steel" as used herein means steel in which carbon is the only element employed to control physical properties, although such steel may contain some manganese (less than 1%) with a minimum of impurities including residuals (less than 1% in aggregate). "Low carbon steel," for the purposes of this agreement, is a simple steel having a carbon content of .25% or under. "High carbon steel," for the purposes of this agreement, is a simple steel having a carbon content of more than .25%.

2.

The term "alloy steel" as used herein means a steel which, in addition to carbon, contains another element or elements in sufficient amounts to modify the properties to a marked degree from simple steel. It includes those products generally known in the trade as "stainless steel" and "silicon steel."

3.

"Products" or "steel" as used in this agreement shall be only products or steel rolled on mills owned or operated by CRUCIBLE coming under the Cold Metal

patents, and in the rolling of which one or more of the inventions covered by the Cold Metal patents are utilized.

SECTION II

COLD METAL hereby grants to CRUCIBLE a nonexclusive right and license under said Cold Metal patents (a) to make or have made for its own use mills and equipment coming under the Cold Metal patents, (b) to own and use said mills and equipment, (c) to practice processes coming within the scope of the Cold Metal patents throughout the United States, its territories and possessions, and (d) to use and sell the products of said mills, equipment and processes anywhere in the world.

SECTION III

CRUCIBLE shall pay or cause to be paid to COLD METAL royalties as follows:

1.

For low carbon simple steel rolled on mills or equipment under said Cold Metal patents, according to the following Schedule "A":

	Thickness	Royalty per ton of 2000 pounds
SCHEDULE "A"	.250" and heavier	25¢
	.125" to .249"	50¢
	.060" to .124"	75¢
	Thinner than .060"	$1.00

2.

For high carbon steel rolled on mills or equipment under said Cold Metal patents, $2.00 per ton, irrespective of thickness.

3.

For all other products, including alloy steels, rolled on mills and equipment under the Cold Metal patents,

2½% of the selling price. The selling price shall be determined in the manner set forth in Paragraph 4 hereof.

4.

In respect of all products rolled on the licensed mills and equipment, and sold by CRUCIBLE in the hot rolled condition, in coil or sheet form, the term "selling price" as used herein shall mean the selling price actually charged by CRUCIBLE to the purchaser. As to products rolled on the licensed mills and equipment and either subsequently cold rolled or fabricated into articles by CRUCIBLE from the hot rolled products, the term "selling price" as used herein shall mean the price at which CRUCIBLE is currently selling the particular grade of material, hot rolled in coils or sheets, whichever is lower. If, however, CRUCIBLE is not currently selling such material in the hot rolled condition as aforesaid, then the term "selilng price" as used herein shall mean the prevailing regular market price of such material, hot rolled in coils or sheets, whichever is lower. In the further event, however, that CRUCIBLE is not selling such material hot rolled as aforesaid, and if there is no prevailing regular market price for such material, then, in that event, the term "selling price" as used herein shall maen CRUCIBLE'S cost of said hot rolled product plus 15% thereof, as certified to COLD METAL BY CRUCIBLE supported by the affidavit of CRUCIBLE'S comptroller. In determining said "selling price" none of the following extras charged to the purchaser shall be included:

Cutting to length
Forming
Slitting
Circle cutting or blanking

Plaintiff's Exhibit P-2.

Leveling
Commercial testing
Perforating
Packing
Tolerance for width
Trimming for width
Annealing
Straightening
Pickling
Oiling or Liming

5.

Royalty payments shall be made monthly and shall be due on the twentieth day of each month covering salable production of the previous calendar month. Salable production is defined as all material which is shipped or used. In the case of material being rejected by a customer of CRUCIBLE or by CRUCIBLE and later used by CRUCIBLE as scrap or sold as scrap at scrap prices, no royalty shall be payable to COLD METAL on such material. Each royalty payment shall be accompanied by a statement showing the entire production of royalty-bearing material by CRUCIBLE during the previous month. Each monthly statement shall include a complete report of all rejected material and the disposition made of such material.

6.

CRUCIBLE shall keep or cause to be kept accurate books of account showing the amount of royalty determined under subparagraphs 1, 2 and 3 above, and CRUCIBLE'S books and records relative to actual sales, to its current selling prices, and to the production of products shall be open to the inspection of representatives

of COLD METAL acceptable to CRUCIBLE at any time during reasonable business hours.

7.

It is understood that CRUCIBLE at the present time does not own or operate mills or equipment under said Cold Metal patents, that nevertheless it is presently contemplating the installation of such mills and equipment, but that the installation of such mills and equipment may not be completed for a period of more than one year from the date hereof. Consequently, the royalty rates set forth above in this Section III are the royalties which will become applicable only upon the installation and commercial operation of the licensed mills and equipment, and shall not be considered as effective for any purpose whatsoever until the date when such commercial rolling of steel on the licensed mills and equipment is commenced by CRUCIBLE.

8.

The royalties specified herein shall continue at the full rates set forth in this Section III until the expiration of patent No. 1,977,214 on October 16, 1951. Thereafter, throughout the remaining life of the licenses granted hereby, the royalties payable shall be at the rate of fifty per cent (50%) of the royalty rates specified above. It is understood and agreed, however, that the royalty payments specified herein are to continue only so long as CRUCIBLE'S mills and equipment or operations are covered by unexpired claims of the Cold Metal patents, and this irrespective of the duration of this agreement.

SECTION IV

If COLD METAL shall acquire any further patents within the life of this agreement covering improve-

ments upon the inventions of the patents set forth in Paragraph A hereof, such improvement patents shall be included in this agreement to the same extent as if specificallly listed in Paragraph A hereof, and CRUCIBLE shall be licensed under such improvement patents to the same extent as under the patents specifically listed above in Paragraph A.

SECTION V

In the event that COLD METAL, at any time hereafter, shall grant to another licensee in the United States, its territories or possessions, for the subsequent manufacture of the same materials herein contemplated on reversing hot mills or equipment falling within the scope of one or more of the patents set forth above in Paragraph A, or should amend any existing license agreement so as to grant, more favorable royalty rates than the rates specified in Section III, sub-paragraphs 1, 2 and 3 hereof, the royalty rates for this license shall at the same time be reduced to such more favorable rates for the remaining life of this license. COLD METAL shall promptly disclose to CRUCIBLE the fact of the granting of any more favorable rates than those herein specified.

COLD METAL warrants and represents that, except for licenses hitherto granted by it or by The Cold Metal Process Company (its predecessor in title) to Youngstown Sheet and Tube Company and Dominion Foundries and Steel Limited, neither it nor its said predecessor in title has hitherto granted any license under the Cold Metal patents, or any of them, which provide for royalty rates which are more favorable to the licensee than those herein above specified. Any reduction granted or

ordered by The District Court of the United States for the Eastern District of Michigan, in a suit pending in that Court brought by The Cold Metal Process Company against McLouth Steel Corporation, at Civil 1686, in the royalty rates specified in a license granted by COLD METAL or its predecessor in title to said McLouth Steel Corporation shall not be deemed a grant by COLD METAL of a more favorable license within the meaning of this Section V.

SECTION VI

Unless sooner terminated as hereinafter provided, this agreement shall continue in full force and effect throughout the life of each of said Cold Metal patents which is of such character and scope as to cover the mills or equipment installed or to be installed by CRUCIBLE, or the operation thereof, and shall continue throughout the life of each improvement patent which COLD METAL may hereafter acquire and under which a license is hereby granted to CRUCIBLE.

SECTION VII

If, during the duration of the licenses hereby granted, any claim or claims of any of the Cold Metal patents shall be held invalid or limited by a court from whose decision no appeal is taken or no appeal or other proceeding for review can be taken, then for the purpose of this agreement, said claim or claims shall be considered as if they had expired or as limited by said decision as of the date of the final decree or affirmance of the holding of said court, and royalties payable after the date of said decree or the affirmance of the holding of said court shall be paid only for products rolled on mills coming within the scope of unexpired claims of said patents as limited by said decision.

Plaintiff's Exhibit P-2.

SECTION VIII

COLD METAL shall in good faith endeavor to enforce and maintain valid all of said COLD METAL patents. In case the parties hereto cannot agree as to the steps which COLD METAL should take against an alleged infringer, and COLD METAL does not, in good faith, believe that the bringing of suit is reasonably required for the protection of CRUCIBLE under the licenses herein granted, then the matter shall be submitted to three arbitrators whose judgment shall be final and binding upon the parties hereto. If the arbitrators' decision is in favor of CRUCIBLE, then COLD METAL shall sue such alleged infringer and thereafter diligently prosecute the same to a final adjudication or until said infringement is effectively terminated, but if the decision is in COLD METAL'S favor, then there shall be no obligation to bring suit under the circumstances existing and presented to the arbitrators. COLD METAL shall have a reasonable time to bring suit (not to exceed thirty days) from the date of the decision by the arbitrators in CRUCIBLE'S favor. In case it does not bring suit within such time or does not thereafter diligently prosecute the same as aforesaid, CRUCIBLE shall be relieved of the obligation to pay royalties under Section III, subparagraphs 1, 2, and 3 hereof from the date of the arbitrators' decision up to the date when suit is brought against such alleged infringer and also during any period within which COLD METAL fails diligently to prosecute said suit as aforesaid.

The arbitrators shall be selected in accordance with the provisions of the laws of Pennsylvania governing both original appointment and the filling of vacancies in force at the time the arbitration is invoked. Regard-

less of the place where the dispute arises, arbitration shall be held in Allegheny County, Pennsylvania.

In no event shall COLD METAL be required to litigate its patents against more than one alleged infringer at a time.

SECTION IX

COLD METAL agrees to hold CRUCIBLE harmless, up to the amount of royalties paid to COLD METAL by CRUCIBLE, in the event that suit is brought against CRUCIBLE charging infringement by it of any existing unexpired patent by reason of the use of methods or apparatus indispensible to the use of the inventions covered by the Cold Metal patents under which CRUCIBLE is licensed hereby; provided, however, that CRUCIBLE must notify COLD METAL of the institution of any such suit within ten (10) days after the institution thereof and give COLD METAL the opportunity to come in and defend the same.

SECTION X

The licenses hereby granted are personal to CRUCIBLE and shall not be assigned except as a part of and in conjunction with the sale or assignment of the entire business of CRUCIBLE or the merger or consolidation of CRUCIBLE into or with another company, or the sale or assignment of all that portion of the business of CRUCIBLE in which the licensed mills and equipment are employed. In the event of any such assignment, the terms of the licenses granted hereby shall be binding upon such assignee.

This license shall be assignable by COLD METAL. In case of any such assignment by COLD METAL it shall re-

Plaintiff's Exhibit P-2.

quire the assignee to assume all its obligations hereunder.

SECTION XI

At any time after March 1, 1953, CRUCIBLE shall have the right to cancel this agreement upon giving COLD METAL thirty (30) days advance notice in writing of its intention to cancel.

IN WITNESS WHEREOF, the parties hereto have executed this agreement as of the day and year first above written.

THE COLD METAL PRODUCTS COMPANY

By /s/ W. B. LOCKWOOD
President

Attest:
/s/ W. H. KILCAWLEY

CRUCIBLE STEEL COMPANY OF AMERICA

By /s/ W. H. COLVIN, JR.

Attest:
/s/ K. R. VOGEL

Plaintiff's Exhibit P-3.

March 2, 1937. A. B. MONTGOMERY 2,072,122

ROLLING MILL

Filed Dec. 4, 1934 6 Sheets-Sheet 1

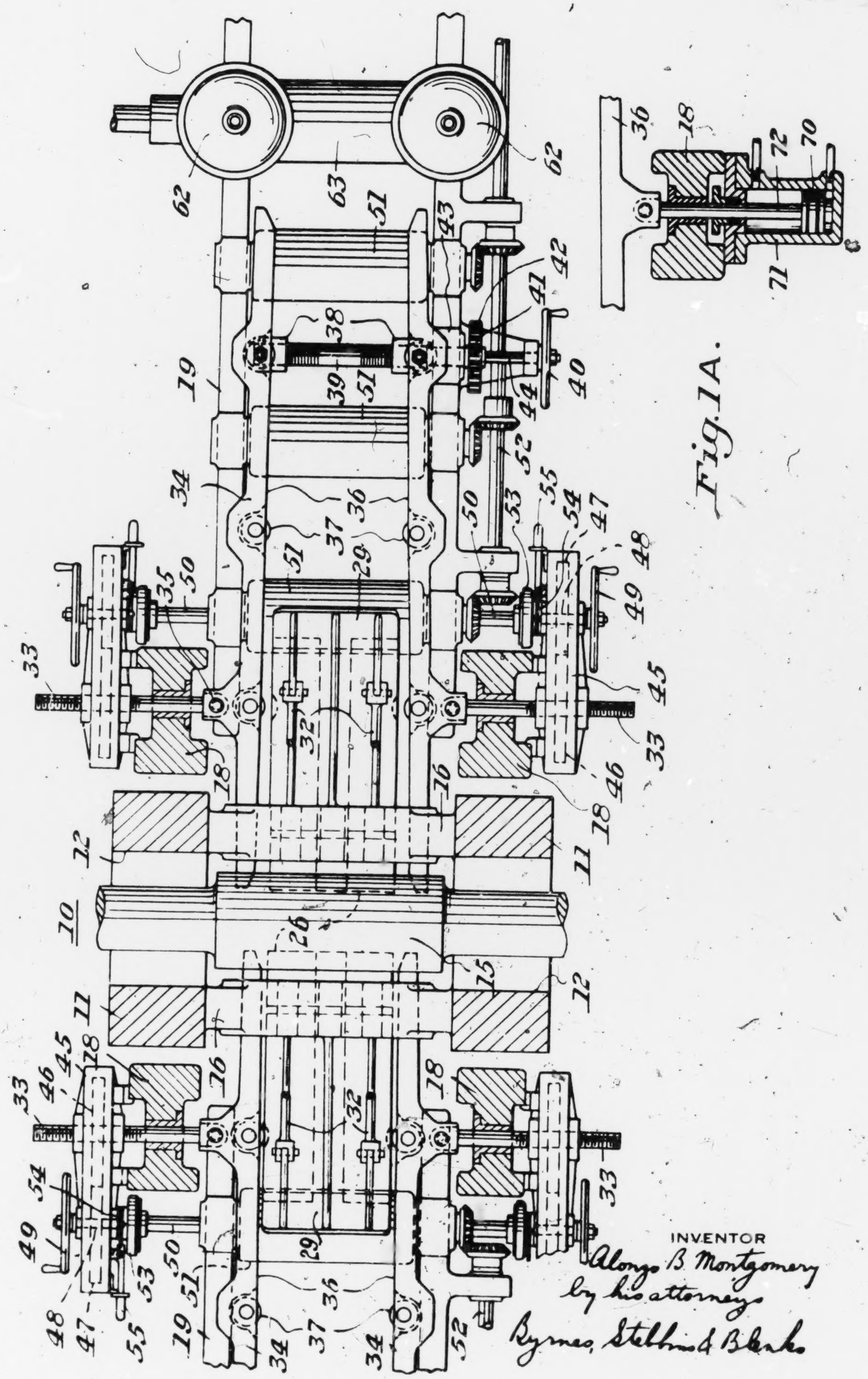


Fig. 1.

Fig. 1A.

INVENTOR
Alonzo B. Montgomery
by his attorneys
Byrnes, Stellman & Black

March 2, 1937. A. B. MONTGOMERY 2,072,122

ROLLING MILL

Filed Dec. 4, 1934 6 Sheets-Sheet 2

Fig. 3.

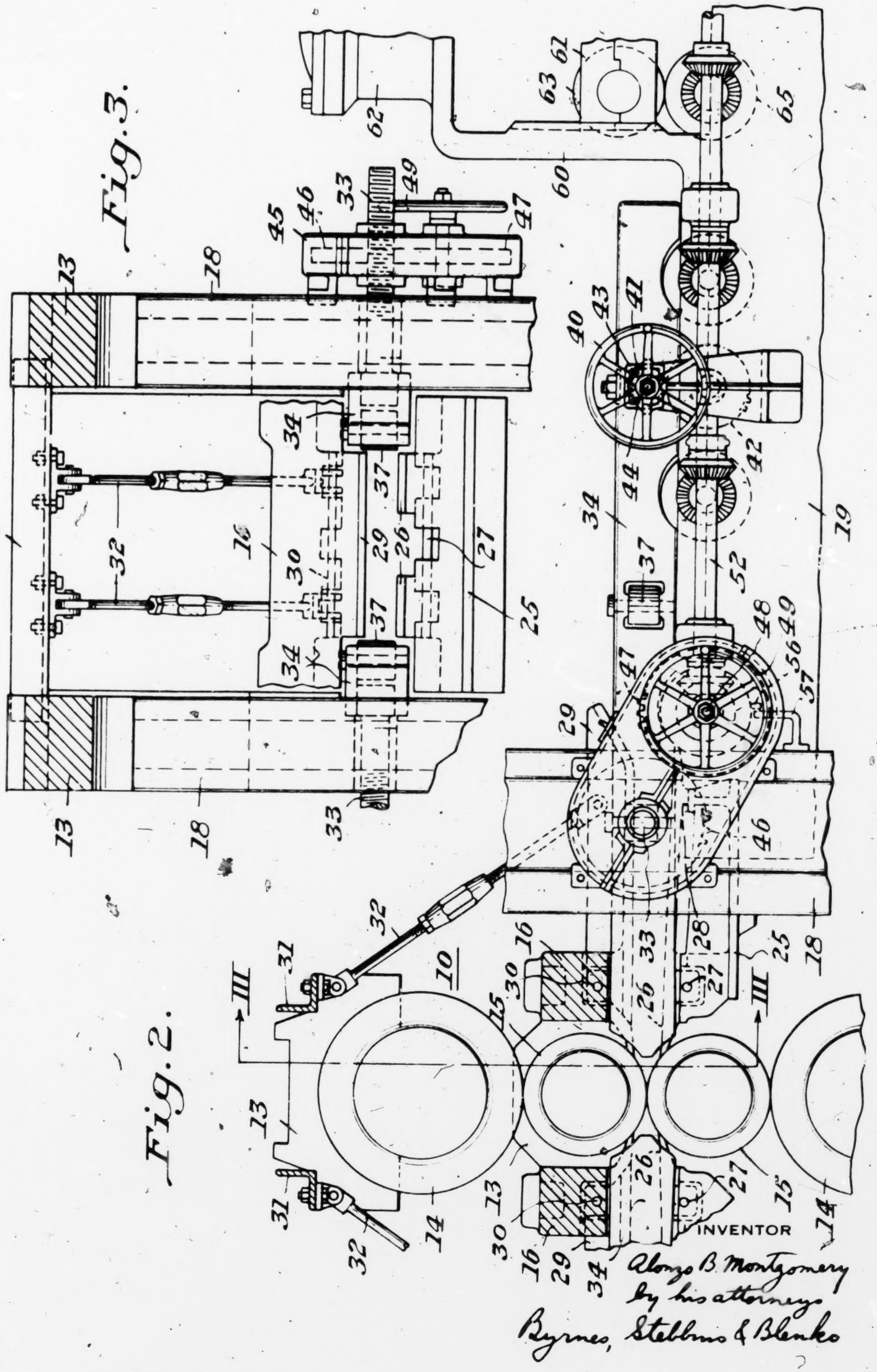


Fig. 2.

INVENTOR

Alonzo B. Montgomery

by his attorneys

Byrnes, Stebbins & Blenko

March 2, 1937. A. B. MONTGOMERY 2,072,122

ROLLING MILL

Filed Dec. 4, 1934 6 Sheets-Sheet 3

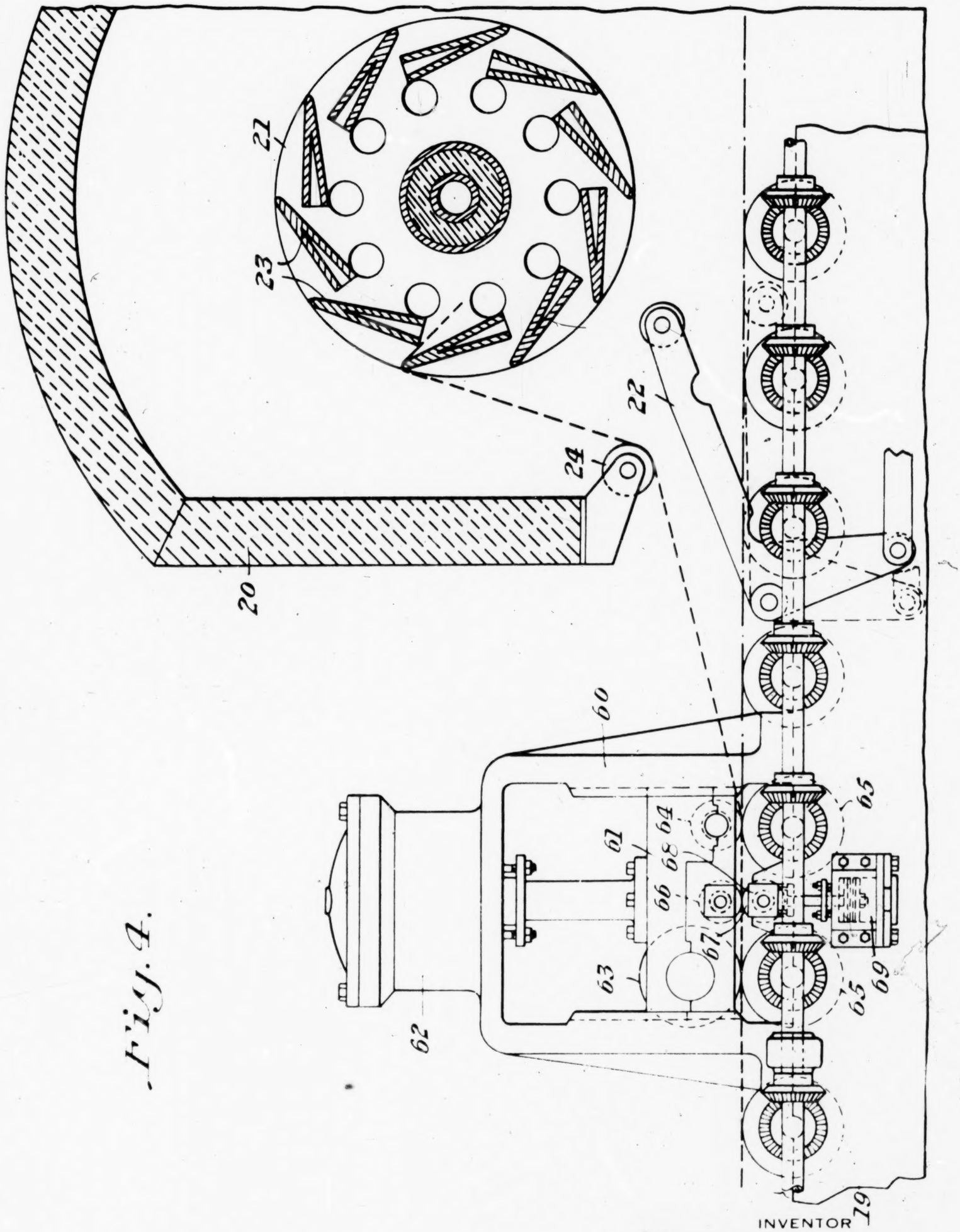


Fig. 4.

INVENTOR
Alonzo B Montgomery
by his attorneys
Byrnes, Stebbins & Blenko

March 2, 1937. A. B. MONTGOMERY 2,072,122

ROLLING MILL

Filed Dec. 4, 1934 6 Sheets-Sheet 4

Fig. 7.

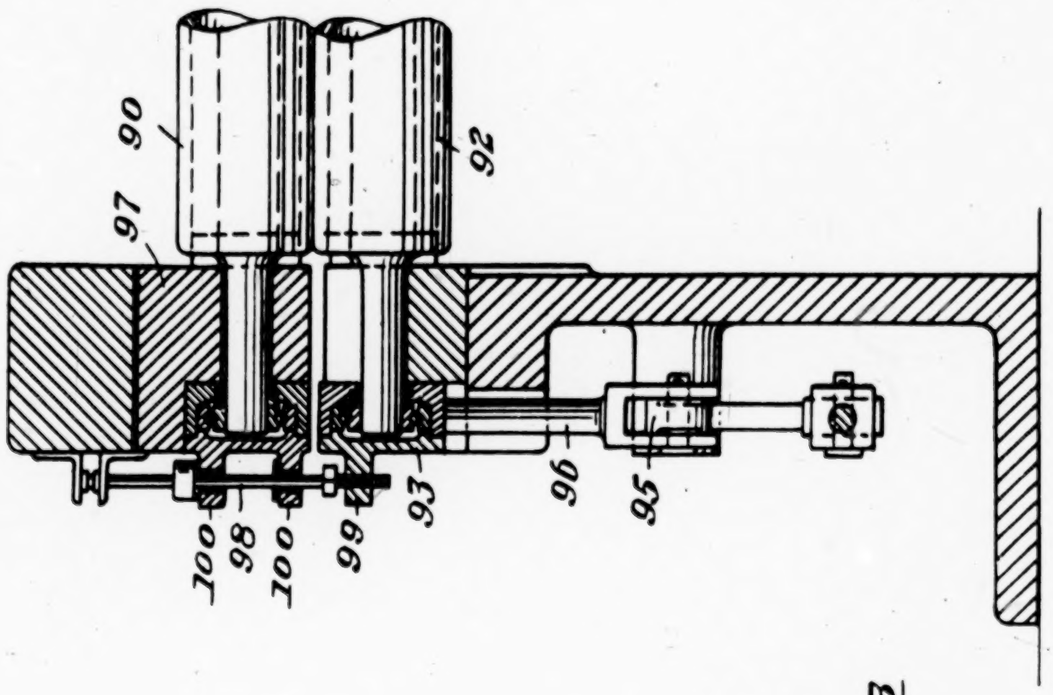
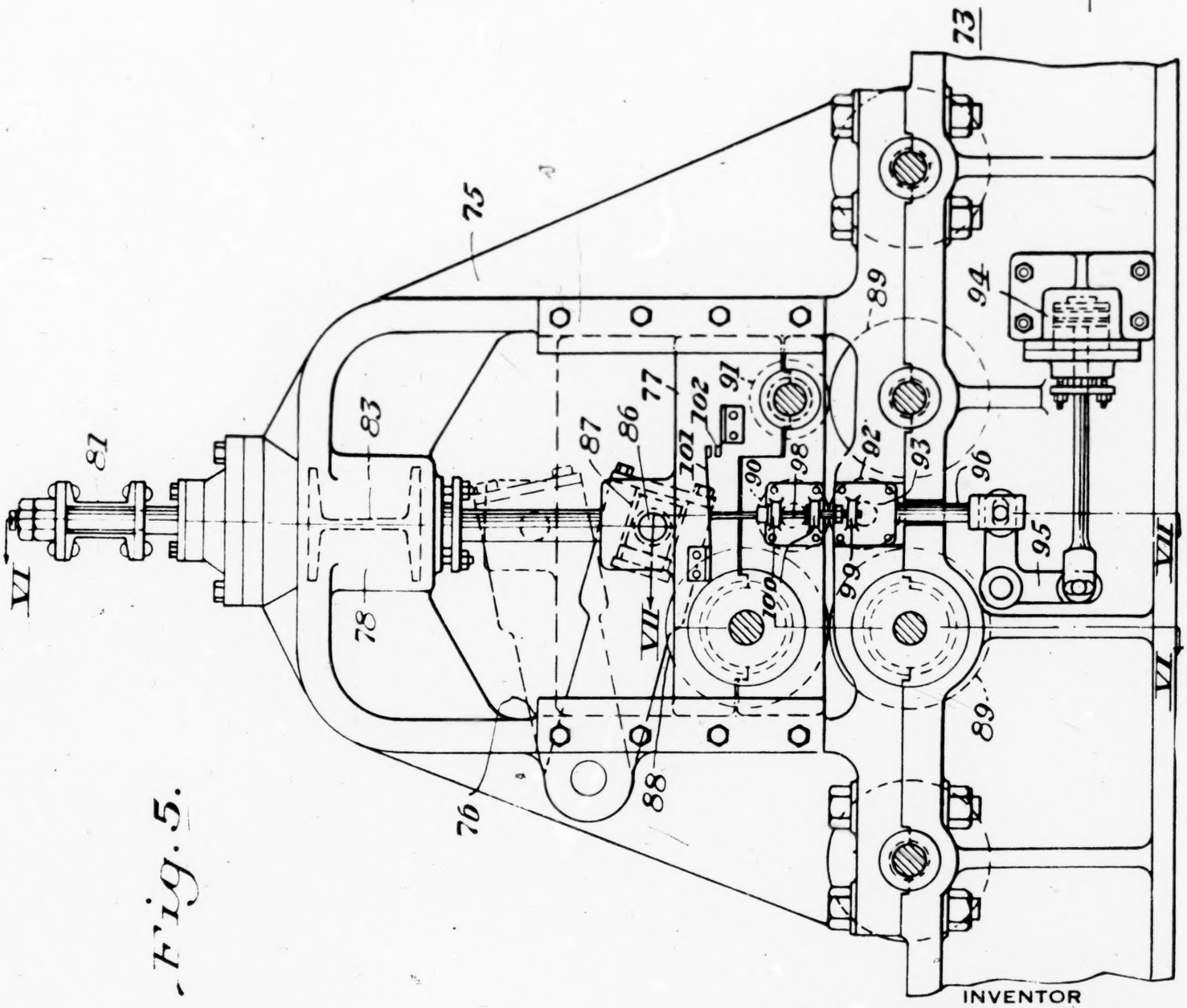


Fig. 5.



INVENTOR

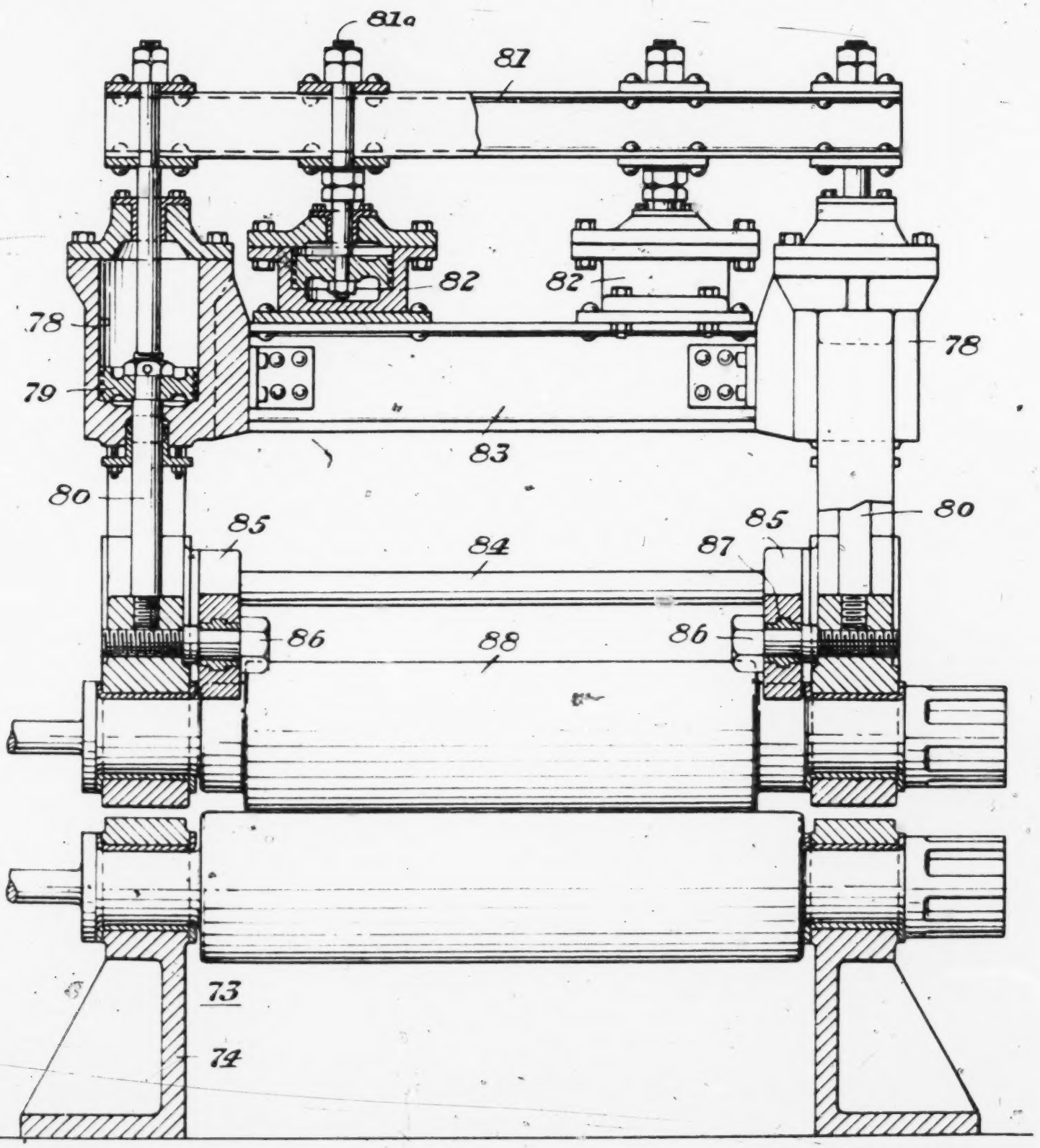
Alonzo B. Montgomery
by his attorneys
Byrnes, Stebbins & Blenko

March 2, 1937. A. B. MONTGOMERY 2,072.122

ROLLING MILL

Filed Dec. 4, 1934 6 Sheets-Sheet 5

Fig. 6.



INVENTOR

Alonzo B. Montgomery

by his attorneys

Byrnes, Stebbins & Blanko

March 2, 1937. A. B. MONTGOMERY 2,072,122

ROLLING MILL

Filed Dec. 4, 1934 6 Sheets-Sheet 6

Fig. 8.

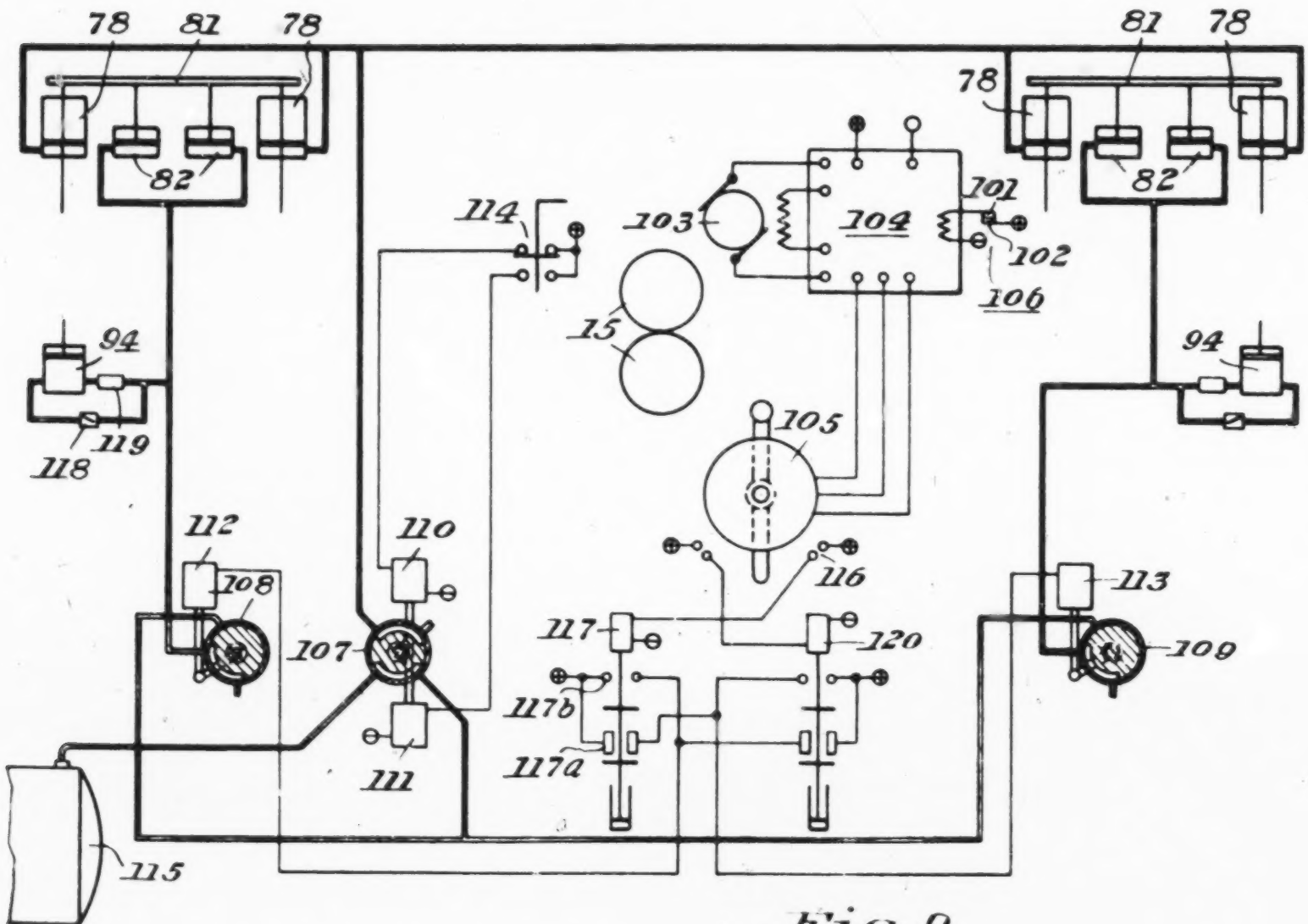
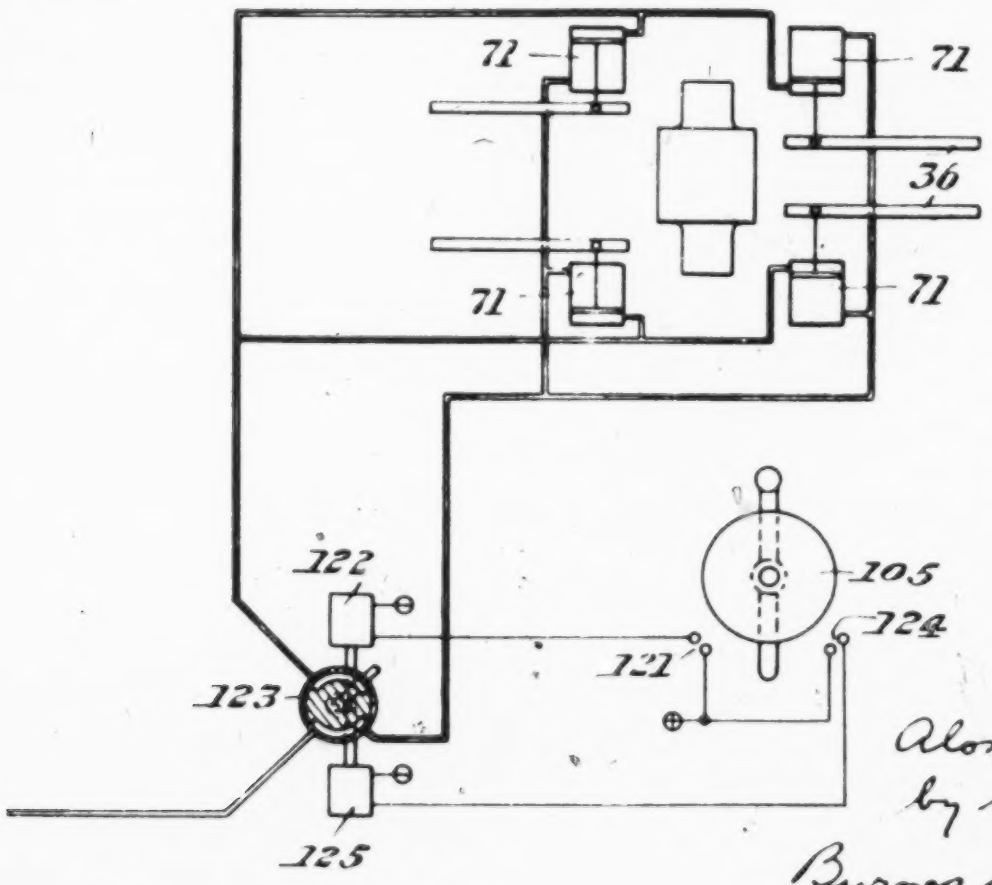


Fig. 9.



INVENTOR

Alonzo B. Montgomery

by his attorneys

Byrnes, Stebbins & Blenko

Patented Mar. 2, 1937 2,072,122

UNITED STATES PATENT OFFICE

2,072,122

ROLLING MILL

Alonzo B. Montgomery, Youngstown, Ohio, assignor to The Cold Metal Process Company, Youngstown, Ohio, a corporation of Ohio

Application December 4, 1934, Serial No. 755,886

20 Claims (Cl. 80—32)

My invention relates to the rolling of metal and, particularly, to the hot rolling of strip and a mill therefor.

In the patents to Keeney et al. No. 1,918,968, and Steckel No. 1,977,214, there are disclosed four-high reversing mills with coiling furnaces on opposite sides thereof for hot rolling strip. My invention is concerned generally with improvements in mills of this type.

Commercial use of mills of the Keeney and Steckel type has disclosed the fact that it is sometimes difficult to cause the material being rolled to enter the rolls properly, namely, at precisely right angles to the plane containing the roll axes. The hot strip, being of comparatively small thickness in the later stages of rolling, has little or no rigidity and it has been found that the strip or the slab from which it is rolled, may become cambered or elongated more along one diagonal than the other if great care is not exercised in directing the piece properly into the mill.

Further difficulty has been experienced in causing the leading end of the material properly to engage the coilers within the furnaces on opposite sides of the mill. It frequently happens that the leading end of the piece becomes bent at a slight angle to the main body thereof and this condition, if not corrected, makes it difficult or impossible to cause the material properly to engage the coiler.

I have invented a rolling mill which overcomes the above-mentioned disadvantages of the known mill construction. In accordance with my invention, I provide side guides on both sides of the mill and operate the guides successively to provide a parallel guiding throat on the entering side of the mill and a tapered guiding throat on the other side of the mill. The conditions of the guides on the two sides of the mills are reversed automatically by a change in the direction of the movement of the piece. Means are provided for adjusting the guides initially to cooperate with material of any desired width within the range of a particular construction.

My invention also includes means for flattening or leveling the leading end of the piece prior to engagement with the furnace coiler. This means takes the form of a series of flattening rolls adjacent the furnace mouth. In passing through the rolls, the end of the strip is straightened or flattened so that proper engagement with the furnace coiler is insured practically without exception.

I also provide pinch rolls for feeding the material toward the mill and, after passing through the mill, toward the coilers, between passes, whereby the strip is properly started on the latter. These pinch rolls are automatically raised when the strip has been properly started. They are also withdrawn when the material being rolled is handled back and forth through the mill in the flat without coiling between passes.

For a complete understanding of the invention, reference should be made to the accompanying drawings illustrating a present preferred embodiment thereof. It is to be understood, however, that other embodiments of the invention may be constructed within the scope of my broader claims. Referring to the drawings:

Figure 1 is a horizontal section through a mill having my invention incorporated therein showing parts in plan;

Figure 1A is a partial, sectional view similar to Figure 1 showing a slightly modified form of construction;

Figure 2 is a partial side elevation with the mill housings removed for the sake of clearness;

Figure 3 is a partial sectional view along the line III—III of Figure 2, showing parts in elevation;

Figure 4 is a partial, vertical section through the coiling furnace showing other parts in elevation to a slightly enlarged scale;

Figure 5 is a side elevation similar to Figure 4 showing a modified form of construction embodying pinch rolls particularly adapted for automatic operation, as well as flattening rolls;

Figure 6 is a vertical, sectional view along the line VI—VI of Figure 5 showing parts in elevation;

Figure 7 is a partial, sectional view along the line VII—VII of Figure 5;

Figure 8 is a schematic diagram of the automatic control system for the apparatus of Figures 5 through 7; and

Figure 9 is a similar view of the system for controlling the guides of Figures 1 through 3.

Referring in detail to the drawings, a mill 10 comprises housings 11 having windows 12 for receiving bearing chucks adjustably positioned therein. Backing rolls 14 and working rolls 15 are journaled in the chucks, the rolls preferably having anti-friction bearings, not shown. The housings 11 are connected by transoms 16.

Auxiliary housings 18 are positioned on opposite sides of the mill. Roll tables 19 extend between the housings 18 for conveying material to and from the mill rolls. Furnaces 20 having coilers 21 therein are positioned at a convenient distance from the mill. Tilting guides 22 are provided on the roll tables 19 for diverting material advancing through the mill from a hori-

zontal path of travel into the coilers 21. These coilers are simply spools of convenient size with suitable driving and control equipment, each spool having blades 23 positioned therein, as shown in Figure 4, so that when the leading end of the strip enters one of the coilers between adjacent blades 23, the rotation of the coiler bends the strip around the leading edge of one of the blades. As shown in Fig. 4, the coiling reel is driven in such direction that the blades on the lower side move in a direction opposite that in which the strip moves. The remainder of the strip is then drawn around a scale-breaking roll 24 at the edge of the furnace mouth and wound up on the coiler.

A base 25 is carried between each of the auxiliary housings 18. Bottom guides 26 are pivotally supported on the bases 25 at 27. The guides 26 are also supported by flat seats 28.

Top guides 29 are pivoted at 30 to the transoms 16 and are suspended from angle bars 31 extending across the mill between the chucks 13 for the top backing rolls, by links 32. The inner ends of the guides 26 and 29 are shaped to conform closely to and are actually in contact with the work rolls to effect a stripping action in case the piece tends to follow around the periphery of one or the other of the rolls.

In the subsequent description of the invention, I shall refer specifically to the equipment on the right-hand side of the mill only, as shown in Figures 1, 2 and 4, but it will be understood that duplicate equipment is employed on the opposite side of the mill.

Screw shafts 33 are slidably mounted in the housing 18 parallel to the axes of the mill rolls. Side guides 34 are supported on the screw shafts 33 by hinged joints 35. The guides 34 have a plane inner surface 36 with recesses into which anti-friction rolls 37 are let. The mill ends of the guides extend to a point closely adjacent the rolls, as shown in Figures 1 and 2. The outer ends of the guides are pivotally supported on nuts 38 traveling on a screw shaft 39 journaled in the side frames of the table 19. The ends of the screw shaft 39 are oppositely threaded so that on rotation of the shaft, the outer ends of the guides are moved toward or away from the center line of the table 19.

From what has been said, it will be apparent that my invention provides side guides which may be disposed in parallel relation, as shown on the left-hand side of the mill in Figure 1, or in angular relation, as shown on the right-hand side of the mill in Figure 1, for the purposes, respectively, of definitely and positively guiding the leading end of an advancing strip into the rolls at the proper angle thereto, and providing a tapering throat for receiving the end of the piece as it emerges from the mill. I shall now describe the mechanism for operating the guide supports to bring about the proper relation of the guides at the proper time.

The outer ends of the guides may be adjusted toward or away from each other through the shaft 39, as already described. This adjustment is effected by a hand wheel 40 having a pinion 41 meshing with a gear 42 along the screw shaft 39. A suitable pedestal bearing 43 is provided for the hand wheel shaft 44. The outer ends of the guides 34 are adjusted manually to the proper spacing before commencing the rolling.

The adjustment of the inner ends of the guides 34 is effected through the screw shafts 33. Gear cases 45 attached to the housings 18 enclose gear wheels 46 having their bores threaded for engagement with the shafts 33, and pinions 47 keyed to shafts 48. Hand wheels 49 permit manual adjustment of the screw shafts 33. These shafts are normally driven from extensions 50 of the shaft of one of the rolls 51 of the table 19. The rolls of the table are driven from a line shaft 52 through the usual bevel gears by a reversing motor, not shown. Between the shaft extensions 50 and the shafts 48 are positioned friction clutches 53 and jaw clutches 54 having operating levers 55. The purpose of the friction clutches is to permit the rotation of the shaft 48 to be arrested after a predetermined movement thereof without stopping the operation of the roll 51. The jaw clutches 54 permit the shafts 33 to be freed from the table drive while being manually adjusted.

The friction clutches 53 have detents 56 thereon cooperating with stops 57 on the housings 18 to limit rotation of the shaft 48 to the desired extent. After the detents engage the stops, the adjustment of the shafts 33 ceases but the roll 51 continues rotating with accompanying slippage of the clutches 53.

It will now be apparent that once the outer ends of the guides 34 have been adjusted, the inner ends of the guides will be spread to form a tapering throat or moved together to parallel position with the reversal of the drive for the rolls of table 19. The detents and stops controlling the amount of rotation of the friction clutches will determine the amount of movement imparted to the inner ends of the guides and may, if desired, be made adjustable. It will be understood, of course, that the guide-operating mechanism is designed so that the guides will be spread at the mill end when the table rolls are driven in such a direction as to move material away from the mill. At the same time, the guides on the opposite side of the mill will be actuated to parallel position. In this way, the material advancing toward the mill is definitely and positively alined at right angles to the plane containing the axes of the mill rolls. The emerging material is in no wise obstructed but is gently received within a slightly tapering guiding throat. In both cases, the anti-friction rolls 37 prevent binding and insure continuous, steady forward movement of the material without grabbing or slipping. As before stated, the extreme positions of the inner ends of the guides may be adjusted initially by hand after disengaging the clutches 54. Thereafter, the range of movement of the inner ends of the guides is determined by the location of the detents 56 and stops 57. In the construction illustrated, I have assumed that one complete revolution of the shaft 58 will produce the necessary movement of the inner ends of the guides.

Referring now particularly to Figure 4 for a disclosure of the flattening rolls, housings 60 supported on side members of the roll table 19 have bearing chucks 61 movable vertically therein by means of a pneumatic cylinder 62. Rolls 63 and 64 journaled in the chucks 61 cooperate with adjacent rolls 65 of the table 19. A roll 66 also journaled in the chuck 61 cooperates with a roll 67 journaled in adjustable chucks 68. The chucks 68 are actuated by pneumatic cylinders 69.

The rolls 63 and 65 may be driven and when the former is lowered into engagement with the latter, they serve as pinch rolls to feed the strip toward the mill from the coiler 21. When the

strip has been started through the mill and engages the coiler on the opposite side thereof, the chucks 61 are preferably raised and the rolls 63, 64 and 66 lifted off the strip. The chucks 68 of the rolls 67 are preferably lifted at the same time as the chucks 61. In its normal lower position, however, the roll 67 is effective to assist in flattening or leveling the leading end of the material in its passage from the mill to the coiler. The pinch rolls 63 are lowered, of course, at this time. If the leading end, after passing through the pinch rolls, is deflected downward, it will engage the roll 67 and then the roll 65. On passing between the rolls 64 and 65, the end will be flattened sufficiently to engage the coiler 21 without difficulty. Similar results occur if the leading end of the piece is deflected upward, in which case it will engage the rolls 66 and 64 successively, and after passing between the roll 64 and the roll 65 cooperating therewith, will be found to be satisfactorily flattened. The control of the fluid supplied to the cylinders 62 and 69 has not been illustrated since it may be of any desired character, automatic or manual.

Figure 1A illustrates a modified form of actuating mechanism for the guides 36. This means takes the form of pistons 70 reciprocable in cylinders 71 by means of fluid pressure, hydraulic or pneumatic, supplied thereto. The pistons 70 have piston rods 72 attached thereto corresponding to the screw shafts 33 and functioning in the same way, under the influence of fluid pressure admitted to either side of the cylinders 71 for actuating the guides.

A modified form of construction of the auxiliary rolls for feeding and flattening the strip is shown in Figures 5 through 7. A roll table 73 has side frame castings 74. Housings 75 are attached to the castings 74 and have windows 76 therein in which bearing chucks 77 are slidable. Cylinders 78 formed in the upper part of the housings 75 have pistons 79 reciprocating therein. Piston rods 80 attached to the pistons 79 are threaded into the chucks 77 whereby the latter may be lifted to the dotted line position shown in Figure 5. Piston rods 80 extend outwardly through the upper end of the cylinders 78 and are connected by cross beams 81. Cylinders 82 carried on a transom 83 extending between the housings, also have pistons and piston rods arranged as shown in Figure 6 whereby the beams 81 and, therefore, the chucks 77, may be raised through a small distance. The piston rods of the cylinders 82 have separable, abutting engagement with bolts 81a. It will be apparent that the cylinders 79 and 82 provide independent means for lifting the chucks 77 through a long stroke and a short stroke, respectively. The object of this arrangement will become apparent as the description proceeds.

An equalizing shaft 84 extends between the housings 75 and is journaled therein. Cranks 85 keyed to the shaft 84 carry trunnions 86 in slidable bearings blocks 87. The trunnions 86 are threaded into the chucks 77, as best shown in Figure 6. The equalizing shaft obviously serves to effect simultaneous and equal movement of both bearing chucks and prevents binding of the reciprocating mechanism.

A top pinch roll 88 is journaled in the chucks 77 for cooperation with a bottom pinch roll 89, which may conveniently be one of the rollers of the table 73. Flattening rolls 90 and 91 are also journaled in the chucks 77. The roll 91 cooperates with a roll of the table 73. A roll 92 is journaled in chucks 93 slidable vertically in the base portions of the housings 75. Cylinders and pistons 94, bell crank linkage 95 and struts 96 are provided, as shown in Figure 5 to effect vertical movement of the chucks 93 for a purpose which will appear later.

As best shown in Figure 7, the roll 90 is journaled in chucks 97 secured to the chucks 77. A contact-actuating rod 98 is threaded into a projection 99 from one of the chucks 93. The rod 98 also passes through guides 100 projecting from one of the chucks 97. The rod 98 controls the engagement of a moving contact 101 with a fixed contact 102 on one of the chucks 77 for a purpose which will presently appear.

The chucks 93 are normally lowered so that contact 101 engages contact 102. These contacts control a circuit for stopping the main mill motor in case of breakage of the strip. When the strip is being rolled, the rolls 88, 90 and 91 rest on the strip and are spaced thereby from the rolls 89 and 92. After the strip has been entered into the mill so as to separate the pinch rolls 88 and 89, fluid is admitted to the cylinders 94 to cause the chucks 93 to be raised until the roll 92 engages the lower surface of the strip. The rolling operation then proceeds. If breakage of the strip should occur, the continuing fluid pressure in the cylinders 94 causes the chucks 93 to rise until the roll 92 actually engages the roll 90. This causes the rod 98 to move upwardly and lift contact 101 out of engagement with contact 102. Separation of these contacts, through suitable auxiliary equipment, causes stoppage of the main mill motor.

The cylinders 79 and 82 are automatically controlled to cause the pinch rolls 88 and 89 to engage the material at certain times and to release it at other times.

In rolling a slab into strip on the mill 10, it is desirable that the pinch rolls 88 be withdrawn as long as the slab being reduced has sufficient rigidity to permit it to be fed back and forth to and from the mill by the friction of the table rolls. When the slab has been reduced to a gauge such that it has relatively little rigidity, or to a condition in which coiling between passes is advisable, the pinch rolls are advanced to assist in threading the strip through the mill at the beginning of each pass. While both ends of the strip actually pass through the mill, the pinch roll motors are so controlled that neither end of the strip is disengaged from the pinch rolls on both sides of the mill. At least one end of the strip is always engaged by at least one set of pinch rolls. It is by these pinch rolls that the strip is then fed back to the mill for the next pass. On the exit side of the mill, the pinch rolls assist in delivering the leading end of the strip into the coiler by pushing it up the guide 22.

The system for automatically controlling the pinch rolls will be now explained with reference to Figure 8. In Figure 8, the work rolls of the mill are indicated by the same numeral as in Figures 1 and 2. A motor 103 is provided for driving the mill and the power of the motor may be applied directly to the work rolls 15 or to the backing rolls 14. The motor 103 may be controlled by any suitable control system. For simplicity, I have only illustrated a control panel 104 having incoming power leads, outgoing motor leads, and outgoing control leads extending to a controller 105. The panel 104, of course, will be provided with suitable relays and contactors effective under the control of the controller 105 to cause starting of the motor 103.

The panel 104 also has a relay 106 effective when deenergized to cause stopping of the motor. The specific details of such an arrangement are known and need not be included here. The controller 105, obviously, is effective on being shifted manually in one direction or the other, to cause operation of the motor 103 to drive the mill rolls 15 and thus move the strip through the mill in the desired direction. The supply of fluid to the cylinders 78, 82 and 94 is controlled by a master valve 107 and auxiliary valves 108 and 109. The valve 107 has operating magnets 110 and 111 and the valve is of such character that it remains in the position to which it was last operated until positively actuated therefrom. The valves 108 and 109 have operating magnets 112 and 113. The arrangement of these valves and their operating magnets is such that they remain in the illustrated position until the magnets are energized, and return to the illustrated position when the magnets are deenergized.

The valve 107 is controlled by a limit switch 114 operated by any convenient means, in accordance with the position of the mill screwdowns which determine the thickness of the pass between the rolls and the material itself after passing through the mill. When the space between the mill rolls 15 is greater than a predetermined value, say ¾", the limit switch 114 closes its lower contacts to energize the magnet 111 and move the valve 107 so that fluid under pressure is supplied from a reservoir 115 through suitable piping, to the cylinders 78 on both sides of the mill. The pistons 79 are thereby actuated full stroke to withdraw the upper pinch roll 88 and provide ample free space for the passage back and forth to and from the mill of the slab in the initial stages of its reduction to strip.

When the thickness of the slab has been reduced to a point such that, on the next pass, the mill rolls are spaced apart only ¾" or less, the partially reduced material is sufficiently thinned and elongated to permit of coiling and, at the same time, its rigidity is such that the assistance of the pinch rolls is required to manipulate it through the mill and into the coilers. The limit switch 114 then closes its upper contacts to energize the magnet 110 and operate the valve 107 to the illustrated position. This vents the cylinder 78 and the pistons 79 immediately drop to lower the pinch rolls 88 onto the material. The pinch rolls are driven by any convenient means, at the same peripheral speed as the rolls 15, so as to cooperate therewith in moving the material back and forth.

If it is assumed for the sake of explanation that the breakdown formed from flat rolling the slab was reduced on a pass from left to right, to a gauge such that after the next reduction, it would be less than ¾" thick, as soon as the top roll 15 is lowered to within less than ¾" of the bottom roll, the described operation of the valve 107 will take place and the pinch rolls will seize the breakdown for the next pass from right to left. When all is ready for this pass, the roller operates the handle of the controller 105 to the left, as shown in Figure 8, whereupon the motor 103 is operated so as to drive the rolls 15 and roll the strip from right to left. The pinch roll drive is so coordinated with that of the mill that the pinch rolls 88 are simultaneously operated so as to assist in the feeding of the breakdown.

The movement of the controller 105 bridges contacts 116 to energize a relay 117. The relay 117 has a time delay in its operation, indicated by a dashpot, and after a certain time bridges contacts 117*a* to energize the magnet 113. The relay is adjusted so that the contacts 117*a* will be bridged just after the leading end of the breakdown being rolled passes between the rolls 15. The magnet 113 operates the valve 109 to admit fluid supplied through the valve 107 to the cylinders 82 on the entering side of the mill. The pinch roll 88 on that side is thus lifted from the material.

After a slightly longer time, the relay 117 operates to bridge its contacts 117*b*, maintaining the circuit for the magnet 113 by reason of the fact that the bridging contact slides along the contacts 117*a*. The relay is adjusted so that the contacts 117*b* are bridged after the material has emerged from the mill on the exit side, passed through the pinch rolls, and made one turn about the coiler. The bridging of the contacts 117*b* causes the operation of magnet 113 to shift the valve 109. The cylinders 82 on the exit side of the mill thus operate to raise the associated pinch roll from the strip. The strip is thus free between the winding and unwinding coilers, except where engaged by the mill.

The operation of the valves 109 and 108 described above, also causes the operation of the cylinders 94 on opposite sides of the mill. The roll 92 is thus raised into engagement with the material but is sufficiently spaced thereby from the roll 90 that the contact 101 remains in engagement with the contact 102. The fluid pressure is continuously applied to the cylinders 94 as long as the rolling continues but, unless the strip breaks during rolling, the rolls 90 and 92 are maintained separated and the contacts 101 and 102 remain in engagement. If the strip is broken, the roll 92 is immediately lifted into engagement with the roll 90, whereupon the rod 98 lifts the contact 101 to open the circuit for the relay 106 and thereby stop the motor 103.

When the pass is completed, the controller 105 is restored to neutral position so that the trailing end of the strip stops between the mill and the pinch rolls on the exit side thereof. The relay 117 is thus deenergized and substantially immediately opens its contacts to deenergize magnets 112 and 113. The cylinders 82 are thus exhausted to the atmosphere and the pinch rolls dropped. At the same time, the cylinders 94 are exhausted through check valves 118, the weight of the roll 92 and chucks 93 serving to force the accumulated fluid out of the cylinders. The operating fluid for the cylinders 94 passes initially through expansion valves 119 which slightly delays the lifting of the chucks 93 on starting a pass.

The next pass is accomplished in exactly the same manner. Reversal of the controller 105 energizes the relay 120 and this, in turn, causes sequential lifting of the pinch rolls 88 on the entering and exit sides of the mill. This cycle is repeated until the strip has been reduced to the desired gauge, when it is wound on a coiler beyond the furnace on the exit side of the mill. The top work roll is then lifted by reversal of the screwdowns. The switch 114 closes its lower contacts and operates the valve 107 to admit fluid under pressure again to the cylinders 78, whereby the pinch rolls 88 on both sides of the mill are lifted out of the way for the next flat rolling operation.

Figure 9 shows how the side guide actuators of Figure 1A are controlled. When the controller 105 is shifted so as to cause the material to be fed from left to right, it closes contacts 121. It will be understood that operation of the controller also, through appropriate relays, causes the starting of the motor 103 in the proper direction. The closing of the contacts 121 energizes an operating magnet 122 for a valve 123. This valve is similar to that shown at 107 of Figure 8. The energization of the magnet 122 operates the valve to the position illustrated in Figure 9, in which it delivers fluid under pressure to the inner ends of the cylinders 71 on the exit (left-hand) side of the mill, and to the outer ends of the cylinders on the entering (right-hand) side of the mill. The guides 36 on the entering side are thus closed in, as indicated in Figure 9, while the guides on the exit side are opened to permit free passage of the material as it emerges from the mill.

On the reversal of the direction of rolling, for the next pass, the controller 105 bridges contacts 124 and energizes a magnet 125 to shift the valve 123 to the other position. The reverse operation of the cylinder 71 then takes place to close the guides on the left-hand side and open the guides on the right-hand side.

It will be understood that only a single controller 105 is employed and that it controls contacts 116 and 124, for example, simultaneously, in addition to the other contacts necessary to bring the motor 103 up to operating speed. The system of Figure 9 is shown separately from that of Figure 8 simply because it is a diagrammatic plan, whereas the latter is a diagrammatic elevation, but it will be understood that the two systems are combined and under the common control of the controller 105.

It will be apparent from the foregoing description that my invention provides a rolling mill having numerous advantages over known apparatus of the same kind. In the first place, the slab or strip is definitely guided into the mill along the pass line or longitudinal axis of the mill. There is thus no possibility for the strip to move into the rolls crabwise at a slight angle to the pass line. Cambering of the strip or slab is thus prevented. Free movement of the highly flexible, thin strip from the mill is permitted without obstruction since the guides on the exit side of the mill are automatically retracted to form a tapering guiding throat. The positions of the guides on opposite sides of the mill are reversed automatically with the reversal of the roll tables and the mill so that once the guides have been adjusted, they require no further attention until a different width of material has to be rolled.

The flattening rolls insure that the leading end of the strip will always be sufficiently flat to enter and engage the coiler properly to wind the strip thereon. This avoids the delays experienced heretofore incident to the backing up of the strip and repeating the entry thereof into the coiler after a first unsuccessful attempt.

The top and bottom guides 29 and 26 respectively, with the side guides 34, form a complete guide box and prevent any departure of the strip from the pass level or the horizontal plane through the roll pass. With the guides of my invention, improper entry of the material into the mill is rendered almost impossible. The top guide may be adjusted by a turnbuckle in the links 32. The bottom guide may be similarly adjusted by shimming up the outer end thereof which rests on the seat 28.

The automatic control of the pinch rolls on both sides of the mill insures that the strip will be advanced properly into the mill and, on emerging therefrom, into the coiler, whereupon the pinch rolls will be lifted out of the way when there is no further need for them. The automatic stop mechanism prevents loss, damage or injury in case the strip breaks during a pass.

The positive actuation of the side guides under the control of the main controller causes the strip to be properly started toward the mill and correctly positioned with respect thereto before it actually enters between the mill rolls, after which no effort is sufficient to correct an improper starting of the strip, because of the great force exerted on the strip by the rolls.

The top guide 29 has an important function in preventing the coiling up of the leading end of the piece when rolling in the flat. If it were not for this guide, the slab, in the early stages of its reduction, might bend up sufficiently to escape the side guides altogether, whereupon it might be improperly entered into the mill pass on the next reversal.

Although I have illustrated and described only one embodiment of my invention, it will be apparent that numerous changes therein may be made without departing from the spirit of the invention or the scope of the appended claims.

I claim:

1. In a rolling mill, side guides extending therefrom, pivoted supports for the outer ends of the guides, means for adjusting said supports toward or away from each other, a roll table for feeding material to and from the mill, and means driven from a roll of said table for moving the inner ends of the guides toward and away from each other.

2. In a rolling mill, a pair of side guides pivotally supported adjacent their outer ends, axially movable screw shafts hinged to the guides adjacent their inner ends, a roll table for moving material to or from the mill, means for shifting said screw shafts including nuts thereon, means for driving the roll table, and means including a friction clutch whereby said drive also actuates said nuts.

3. The combination with a hot strip mill and a coiler adapted to receive strip from the mill and wind it into a coil, of means between the mill and the coiler for flattening the leading end of the strip passing from the mill to the coiler.

4. The apparatus defined by claim 3 wherein said flattening means comprises a plurality of leveling rolls.

5. In a method of making strip, the steps including rolling down a hot slab into an elongated strip, coiling the strip between rolling passes, and flattening the leading end of the strip before coiling between passes.

6. In a rolling mill including a pair of housings and work rolls journaled therein, pinch rolls on one side of the mill, and means for raising one of the pinch rolls through a short distance, and independent means for raising the upper pinch rolls through a greater distance.

7. The combination with a rolling mill, of pinch rolls on one side of the mill, one of said rolls being retractible, a motor for driving the mill, a controller for the motor, and means operated by said controller for causing retracting movement of said one of said pinch rolls at a

predetermined time after the starting of the mill motor.

8. The combination with a rolling mill, of pinch rolls on at least one side of the mill for feeding material thereto, one of said pinch rolls being retractible, and means actuated by the setting of the mill for passes of various thickness, whereby to operate said retracting means.

9. The combination with a rolling mill having an adjustable upper roll, of pinch rolls for feeding material to the mill, one of said rolls being retractible, and means operated in accordance with the adjustment of the upper mill roll for controlling retraction of said pinch roll.

10. The combination with a rolling mill having a driving motor and a controller for the motor, of adjustable side guides on both sides of the mill, and means operated by said controller for shifting the guides inwardly on the entrance side of the mill and outwardly on the exit side of the mill.

11. The combination with a rolling mill and a roll table for feeding material thereto, a motor for driving the mill, of a pair of pinch rolls adapted to engage material on the table, at least one of said pinch rolls being movable, means for constantly urging said movable roll into engagement with the material, and means actuated by movement of said movable roll toward the other of said pinch rolls for stopping said motor.

12. The combination with a rolling mill having a driving motor, of a pair of pinch rolls adapted to engage the material moving to or from the mill, one of said rolls being movable, means for normally holding said movable roll in engagement with the material, and means actuated by movement of said one of said rolls into engagement with the other of said rolls for stopping said motor.

13. The combination with a rolling mill, a driving motor therefor and a controller for the motor, of pinch rolls on one side thereof, one of said rolls being movable, means tending to hold said movable roll against the material being rolled, and means responsive to movement of the roll on breakage of the material for stopping the mill motor.

14. The combination with a rolling mill, a driving motor therefor and a controller for the motor, of pinch rolls on one side thereof, one of said rolls being movable, means tending to hold said movable roll against the material being rolled, means responsive to movement of the roll on breakage of the material for stopping the mill motor, and means operated by movement of the controller to start the motor, for rendering said first-mentioned means effective.

15. The combination with a reversing strip mill, and pinch rolls on opposite sides thereof for feeding material to and from the mill, of a pair of side guides on each side of the mill between the mill and the pinch rolls, means pivotally supporting the outer ends of said guides for swinging movement in a horizontal plane, and means for so moving the inner ends thereof as to dispose the guides on the entry side of the mill in parallel relation and those on the exit side of the mill at an angular relation, depending upon the direction of movement of the material through the mill, said first mentioned means being so spaced as to permit the strip to pass freely between the ends of the guides on the exit side and enter the pinch rolls.

16. In a strip mill, a controller for reversing the direction of rotation of the mill, side guides pivoted adjacent their outer end, and means operated by said controller for adjusting the inner ends of the guides toward or away from each other, according to the direction of rotation of the mill.

17. In a strip mill, a pair of side guides on each side of the mill, pinch rolls adjacent the outer ends of the guides and means controlled by the direction of movement of material passing through the mill effective to cause the guides on the entering side to move to parallel relation, and those on the exit side to move to an angular relation forming a tapering throat with its narrowest portion adjacent the pinch rolls whereby accurately to center the material entering the pinch rolls and preventing cambering of the material.

18. In a rolling mill, a pair of housings having work rolls journaled therein, pinch rolls on at least one side of the mill for engaging material being worked in the mill, means for retracting one of said pinch rolls when unused for a substantial period, and independent means for temporarily retracting one of said rolls.

19. The combination with a rolling mill and a roll table for advancing work thereto, of pinch rolls on one side of the mill, one of said pinch rolls being retractible, and means for retracting said roll including fluid pressure-operated cylinders and pistons, one of which has a short stroke for temporarily retracting the roll and the other having a longer stroke for retracting the roll when unused for substantial periods.

20. Strip rolling apparatus comprising a mill, pinch rolls on opposite sides thereof for feeding material to and from the mill, guides between the mill and the pinch rolls, and means for positioning the guides on the entering side of the mill parallel to the pass line whereby to guide positively the material advancing to the mill, said means being also effective to set the guides on the exit side at a slight angle to the pass line forming a converging throat to receive material issuing from the mill and guide it into the pinch rolls while maintaining it centered relative to the pass line.

ALONZO B. MONTGOMERY.

July 13, 1937. A. B. MONTGOMERY 2,087,065

METHOD AND APPARATUS FOR ROLLING

Filed Jan. 19, 1934

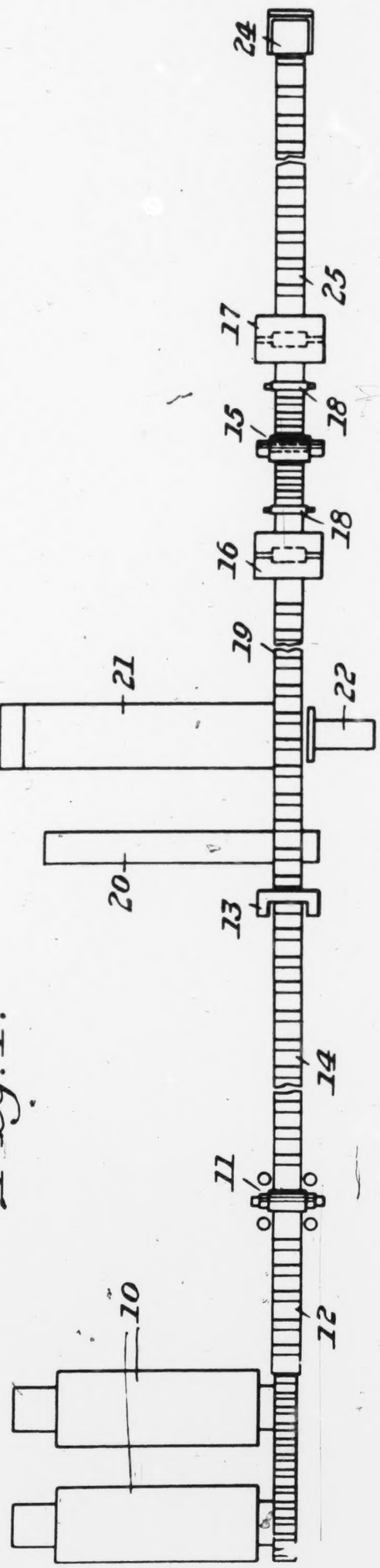


Fig. 1.

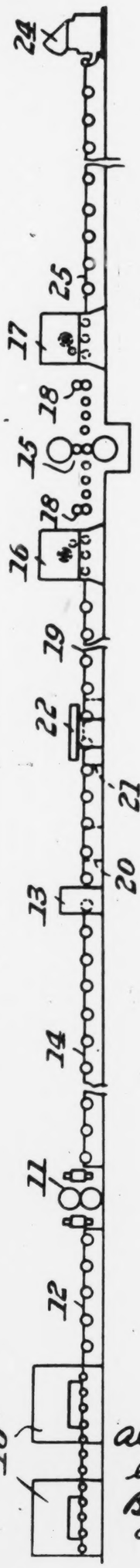


Fig. 2.

INVENTOR
Alonzo B. Montgomery
by his attorneys
Byrnes, Stebbins
& Blenko

Patented July 13, 1937 2,087,065

UNITED STATES PATENT OFFICE

2,087,065

METHOD AND APPARATUS FOR ROLLING

Alonzo B. Montgomery, Youngstown, Ohio, assignor to The Cold Metal Process Company, Youngstown, Ohio, a corporation of Ohio

Application January 19, 1934, Serial No. 707,401

5 Claims. (Cl. 80—40)

My invention relates to the rolling of metal and particularly to long lengths of thin sheet metal, such as strip.

In the U. S. patent granted July 18, 1933 to Keeney, et al., No. 1,918,968, there is disclosed a four-high reversing mill with heating furnaces on opposite sides thereof for hot rolling strip. My invention is concerned chiefly with improvements upon the method and apparatus disclosed in said patent.

For certain classes of product, it is desirable to provide a finish on the hot strip superior to that which can be obtained with the mill shown in the Keeney patent, in which the entire reduction from the slab to the strip is effected by the same rolls. In order to roll a slab in the Keeney mill, the slab must be highly heated, specifically, above the temperature at which free scaling occurs. The presence of the scale on the slab roughens the rolls and precludes the obtaining of a high finish on the hot strip of final gauge. The rolls thus wear rapidly and require frequent changing. The output, furthermore, is limited because of the fact that the slabbing operation is necessarily slow due to the frequent reversals of the mill, and full advantage of the capacity of the four-high mill for high-speed operation is realized only during a portion of the operating cycle, namely, during the rolling with coiling.

In rolling strip from slabs on the Keeney mill, in addition, the effect of the edging rolls used to control and assist in the removal of scale, is to cause the production of ears or projections at the corners of the slab as it is reduced to strip form. These ears make it difficult to direct material on to the coiler for the continuation of the hot rolling.

In accordance with my invention, I take a slab after it has been properly heated in a suitable furnace and subject it to repeated passes through a universal mill to elongate it considerably without materially increasing its width. The ends of the piece are then sheared off to remove the ears projecting therefrom. The material is then passed into another reversing mill, e. g., that of the Keeney patent, with heating furnaces on opposite sides thereof, where it is subjected to further rolling with coiling between passes. After the material has been reduced sufficiently in the four-high mill, it is wound on a final coiler.

For a complete understanding of the invention, reference is made to the accompanying drawing illustrating diagrammatically a present preferred embodiment of the invention and the method of its practice.

Referring in detail to the drawing, furnaces 10 are provided for heating slabs for delivery to a universal mill 11. As is well known, the universal mill is a two-high reversing mill with one or more pairs of vertical rolls or edgers. A roll table 12 extends from the furnaces to the mill. A slab shear 13 is positioned at a suitable distance ahead of the mill 11 with a connecting roll table 14 therebetween.

A second reversing mill 15, preferably but not necessarily a four-high mill, has coil-heating furnaces 16 and 17 on opposite sides thereof, and pinch rolls 18 between the coil furnaces and the mill rolls. A roll table 19 connects the shear 13 and the mill 15. A crop conveyor 20 and a slab conveyor 21, with an associated pusher 22, extends laterally from the table 19. A hot strip coiler 24 is located beyond the mill 15. Roll tables 25 connect the mill 15 and the coiler 24.

The operation of the apparatus above enumerated to perform the method of my invention, may be described briefly as follows: The slabs are fed into the furnaces 10 to be heated prior to rolling in the mill 11. The slabs are initially 2" to 14" thick and of suitable width and length to provide the desired dimensions of finished hot strip. The heated slabs are passed back and forth through the universal mill 11, which effects a slabbing operation, until the slab is reduced to a thickness of ½" or less, with a corresponding elongation, and is cooled to a point where free scaling substantially ceases. The partially reduced slab is then forwarded to the four-high mill 15. The ends of the hot slab, however, are sheared off by the shear 13 before the piece arrives at the coiling mill.

Generally, I prefer to perform all slabbing operations on the mill 11 and thereby reduce the material to a gauge suitable for coiling before advancing it to the mill 15. The material enters the mill 15 while still hot and is coiled up in the coil-heating furnace 17 after the first pass through the mill. On the next pass, the material is coiled in the heating furnace 16. This cycle is repeated and the partially reduced slab is gradually elongated to strip form, the heat lost from the strip by radiation, and otherwise, being supplied during the interval it dwells in the coil-heating furnaces.

When the strip has been reduced to final gauge, say .065", it is advanced from the mill 15 in the flat form along the table 25 toward the final coiler 24. After the strip has been coiled on the coiler 24, and cooled, it is ready for shipment

or further processing, for example, by cold rolling

While I have stated that it is preferable to perform all the slabbing operations on the mill 11, it is possible that in certain cases it may be desirable to effect some reduction of the material in the flat on the mill 15.

It will be apparent to those skilled in the art that the invention described is characterized by numerous advantages over the practice and apparatus heretofore employed. In the first place, a higher finish can be obtained than by using the four-high mill for both slabbing and coiling operations. Since the slabbing operation is confined to the universal mill, by far the greatest portion of free scaling has occurred before the material reaches the four-high mill, at which time it is characterized by a tight, thin layer of oxide which adheres to the strip throughout the further rolling. Excessive accumulation of scale in the four-high mill is thus prevented, as well as the resulting injury to the surface of the working rolls. The output of the four-high mill is increased from 25 to 30%, furthermore, because of the fact that it is operating at high speeds a greater portion of the time than when slabbing operations are effected therein. The high speeds of which the mill is capable, of course, can best be taken advantage of when rolling the longer lengths. The reduction in the wear on the rolls of the four-high mill makes it unnecessary to change rolls as frequently as has heretofore been the case. The shearing of the ends of the partly reduced slab before rolling, greatly facilitates the entry of the material into the furnace reels, making the operation of the mill 15 more efficient and avoiding the delays and loss of material incident to repeated efforts to cause the end of the piece to engage the reel. While I have described the cropping of the ends of the slab as taking place between the slabbing and the rolling with coiling, it is obvious that where some slabbing is done on the four-high mill, the shearing may be performed after such final slabbing.

Although I have illustrated and described but a single preferred embodiment of my invention with certain possible modifications thereof, it will be understood that numerous changes in the apparatus and practice disclosed may be made without departing from the spirit of my invention or the scope of the appended claims.

I claim:

1. In a method of rolling metal strip, the steps consisting in supplying to a roughing mill a heated slab-like body which is too thick for coiling, rolling the body in the roughing mill until it is substantially thin enough to permit of coiling, but maintaining the thinned body in the flat state, and, in the same heat, feeding the thinned body to a reversing mill, subjecting it to successive passes therein to reduce it to a desired strip thickness, and coiling it between passes in the reversing mill.

2. In a method of rolling metal strip, the steps consisting in supplying to a roughing mill a heated slab-like body which is too thick for coiling, rolling the body in the roughing mill until it is substantially thin enough to permit of coiling, but maintaining the thinned body in the flat state, trueing the edges in said mill, and, in the same heat, feeding the thinned body to a reversing mill, subjecting it to successive passes therein to reduce it to a desired strip thickness, and coiling it between passes in the reversing mill.

3. In a method of rolling metal strip, the steps consisting in supplying to a roughing mill a heated slab-like body which is too thick for coiling, rolling the body back and forth in the roughing mill until it is substantially thin enough to permit of coiling, but maintaining the thinned body in the flat state, and, in the same heat, feeding the thinned body to a reversing mill, subjecting it to successive passes therein to reduce it to a desired strip thickness, and coiling it between passes in the reversing mill.

4. In a method of rolling metal strip, the steps consisting in supplying to a roughing mill a heated slab-like body which is too thick for coiling, rolling the body in the roughing mill until the body cools to a temperature below that at which free scale forms, and until it is substantially thin enough to permit of coiling, but maintaining the thinned body in the flat state, and, in the same heat, feeding the thinned body to a reversing mill, subjecting it to successive passes therein to reduce it to a desired strip thickness, and coiling it between passes in the reversing mill.

5. In a method of rolling metal strip, the steps consisting in supplying to a roughing mill a heated slab-like body which is too thick for coiling, rolling the body in the roughing mill until it is substantially thin enough to permit of coiling, but maintaining the thinned body in the flat state, and, in the same heat, feeding the thinned body to a reversing mill after cropping at least one end of the thinned body to facilitate its entry into said reversing mill, subjecting it to successive passes therein to reduce it to a desired strip thickness, and coiling it between passes in the reversing mill.

ALONZO B. MONTGOMERY.

Sept. 10, 1940. A. B. MONTGOMERY 2,214,107

METHOD OF ROLLING

Filed Oct. 23, 1936 6 Sheets-Sheet 1

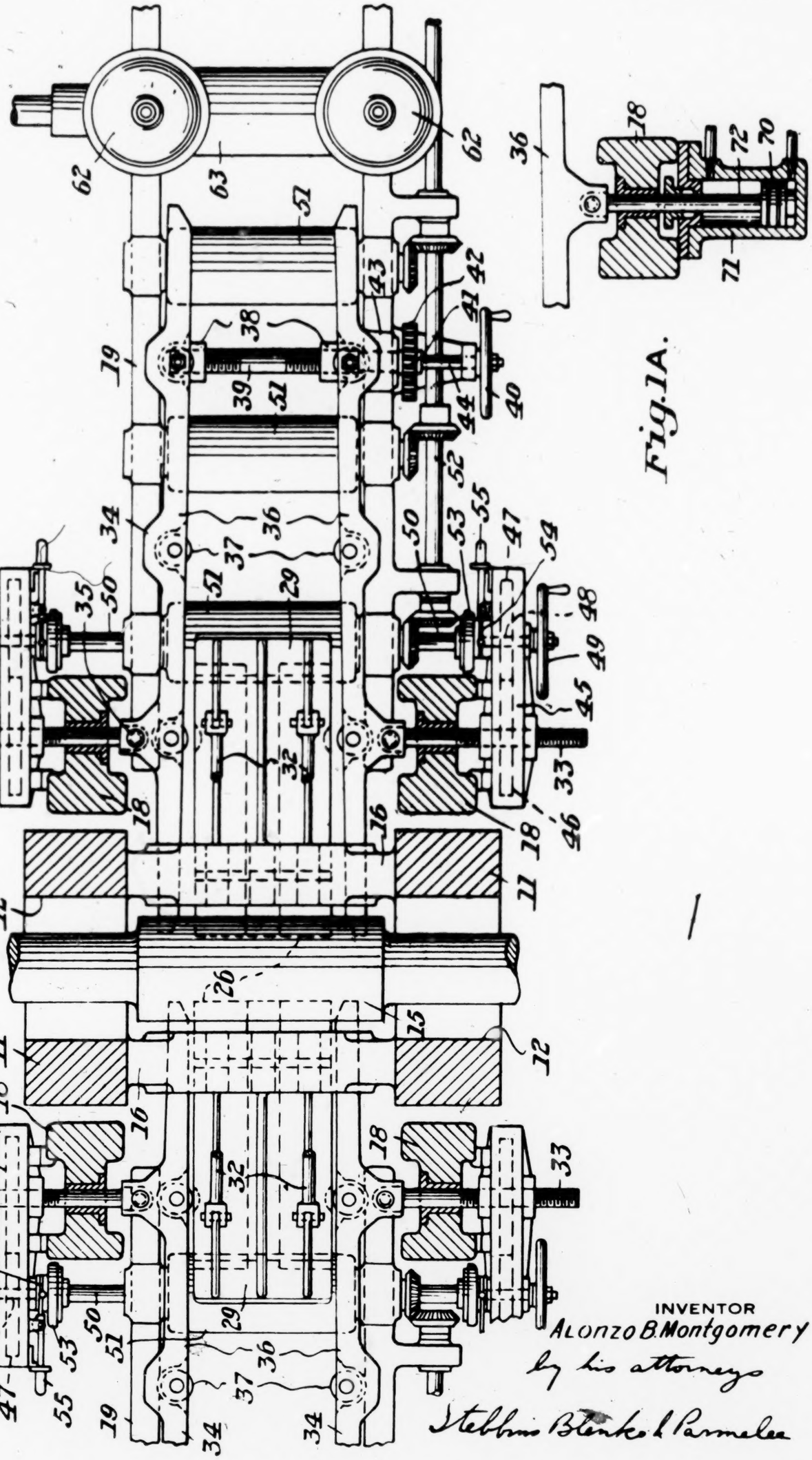


Fig. 1.

Fig. 1A.

INVENTOR
Alonzo B. Montgomery
by his attorneys
Stebbins Blenko & Parmelee

Sept. 10, 1940. A. B. MONTGOMERY 2,214,107

METHOD OF ROLLING

Filed Oct. 23, 1936 6 Sheets-Sheet 2

Fig. 3.

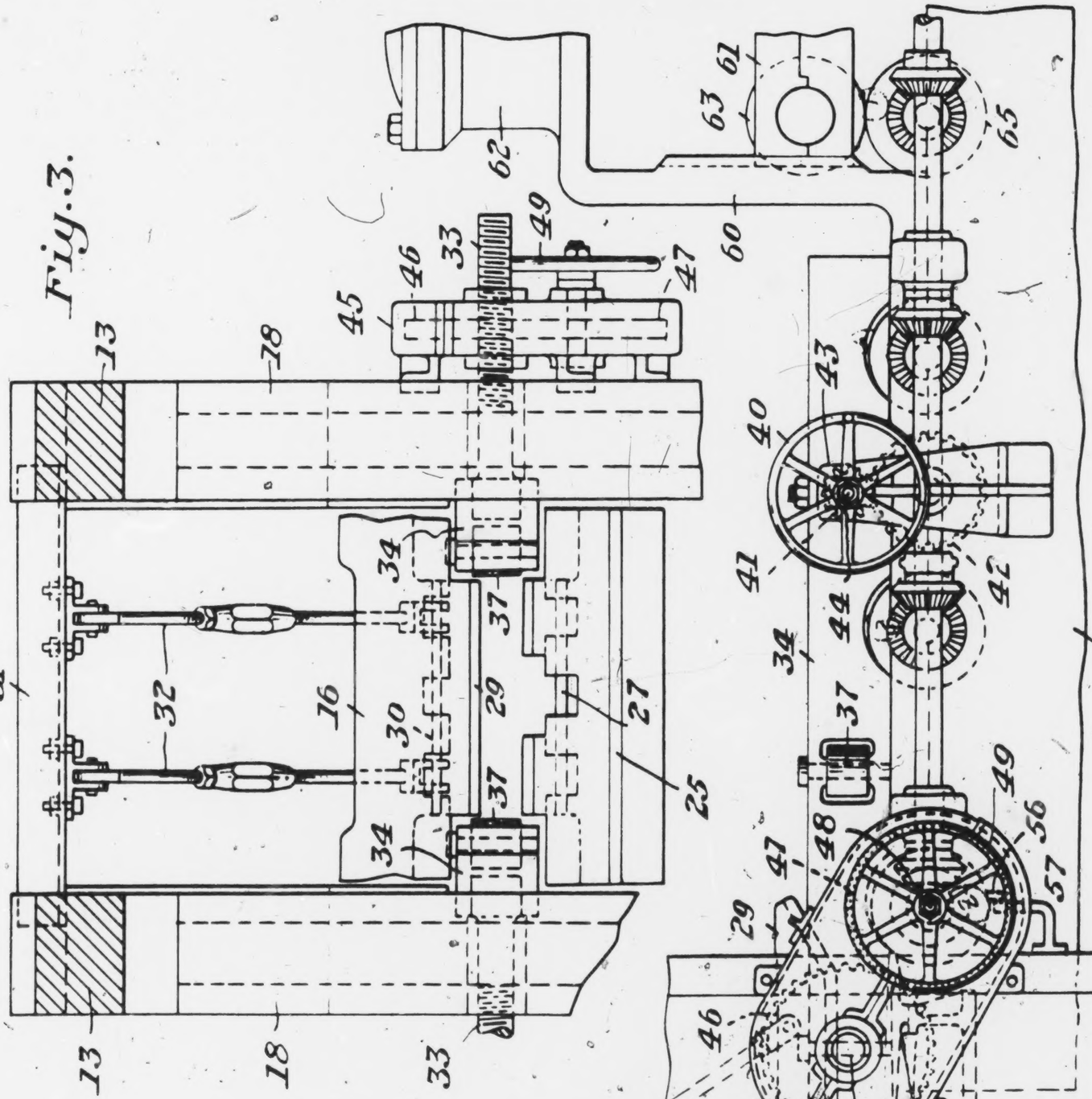
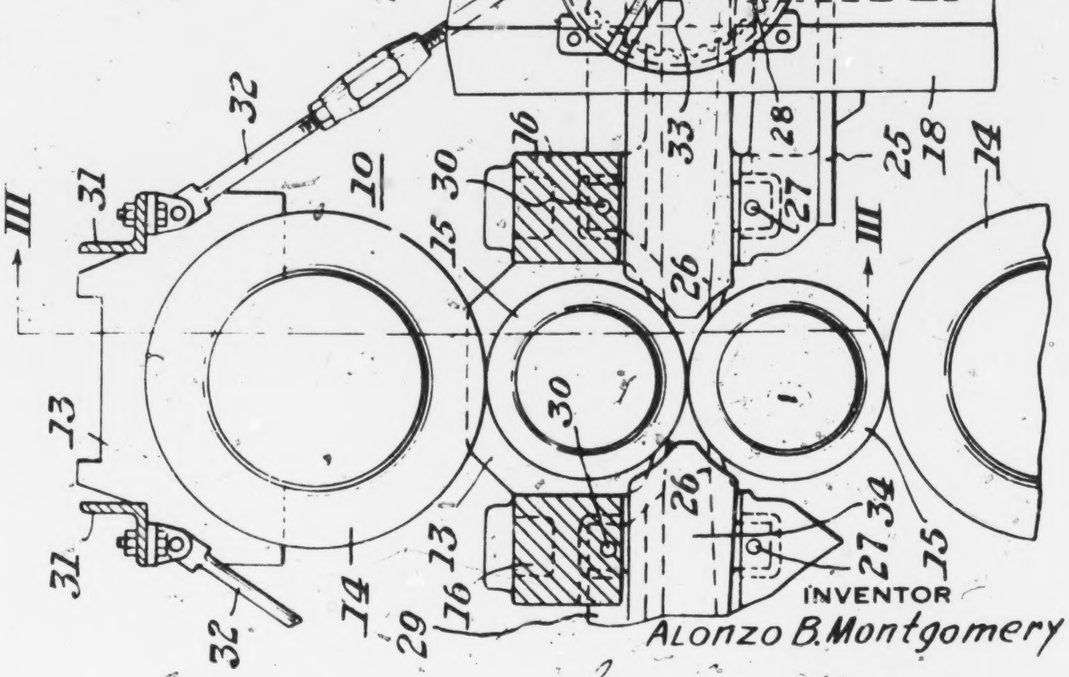


Fig. 2.



INVENTOR
Alonzo B. Montgomery
by his attorneys
Stebbins Blenko & Parmelee

Sept. 10, 1940. A. B. MONTGOMERY 2,214,107

METHOD OF ROLLING

Filed Oct. 23, 1936 6 Sheets-Sheet 3

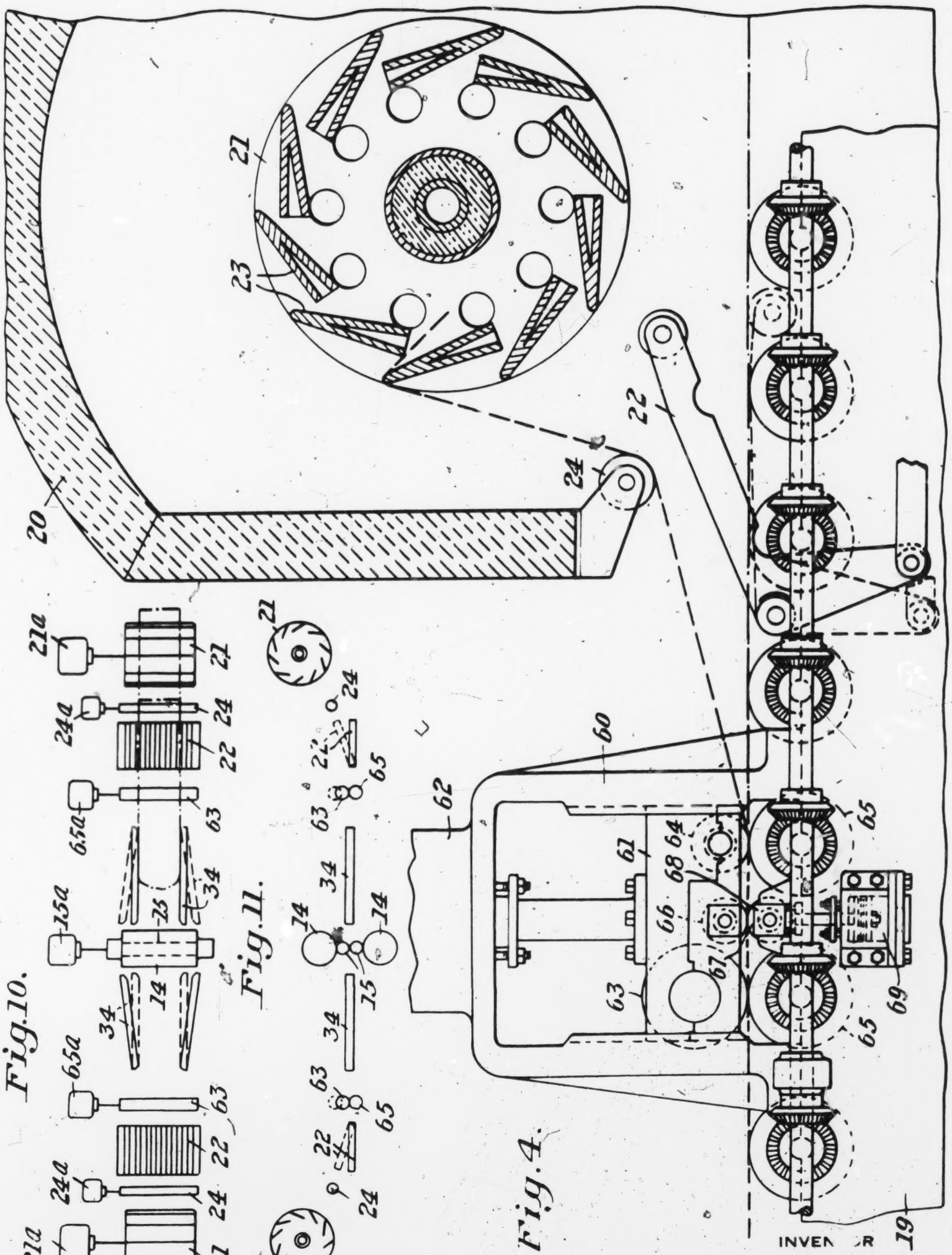


Fig. 4.

Fig. 10.

Fig. 11.

INVENTOR

ALONZO B. MONTGOMERY

by his attorneys

Stebbins, Blenko & Parmelee

Sept. 10, 1940. A. B. MONTGOMERY 2,214,107

METHOD OF ROLLING

Filed Oct. 23, 1936 6 Sheets-Sheet 4

Fig. 7.

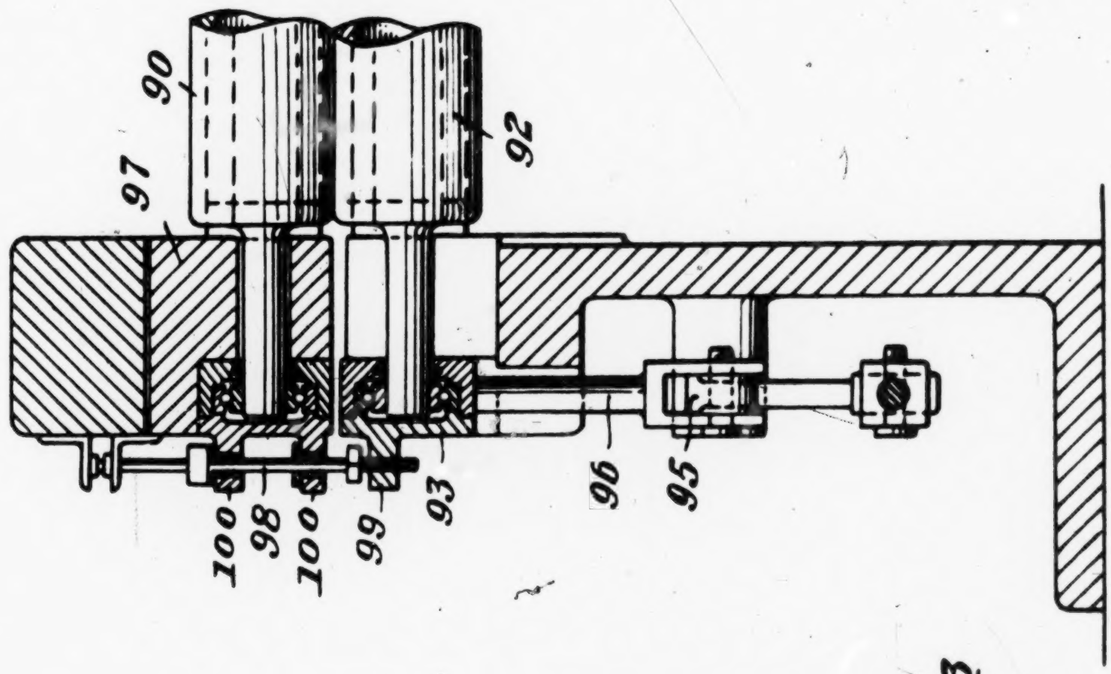
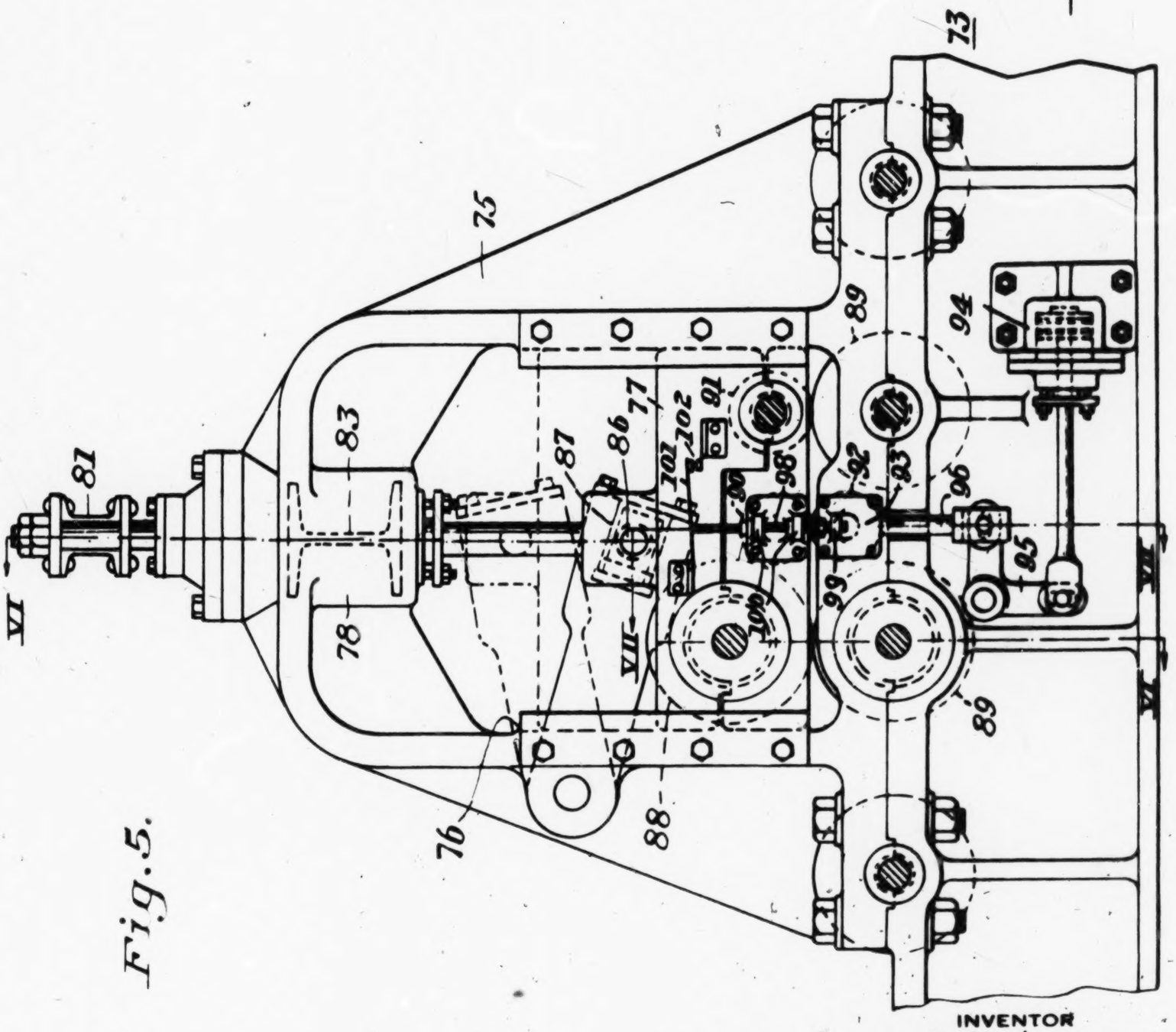


Fig. 5.



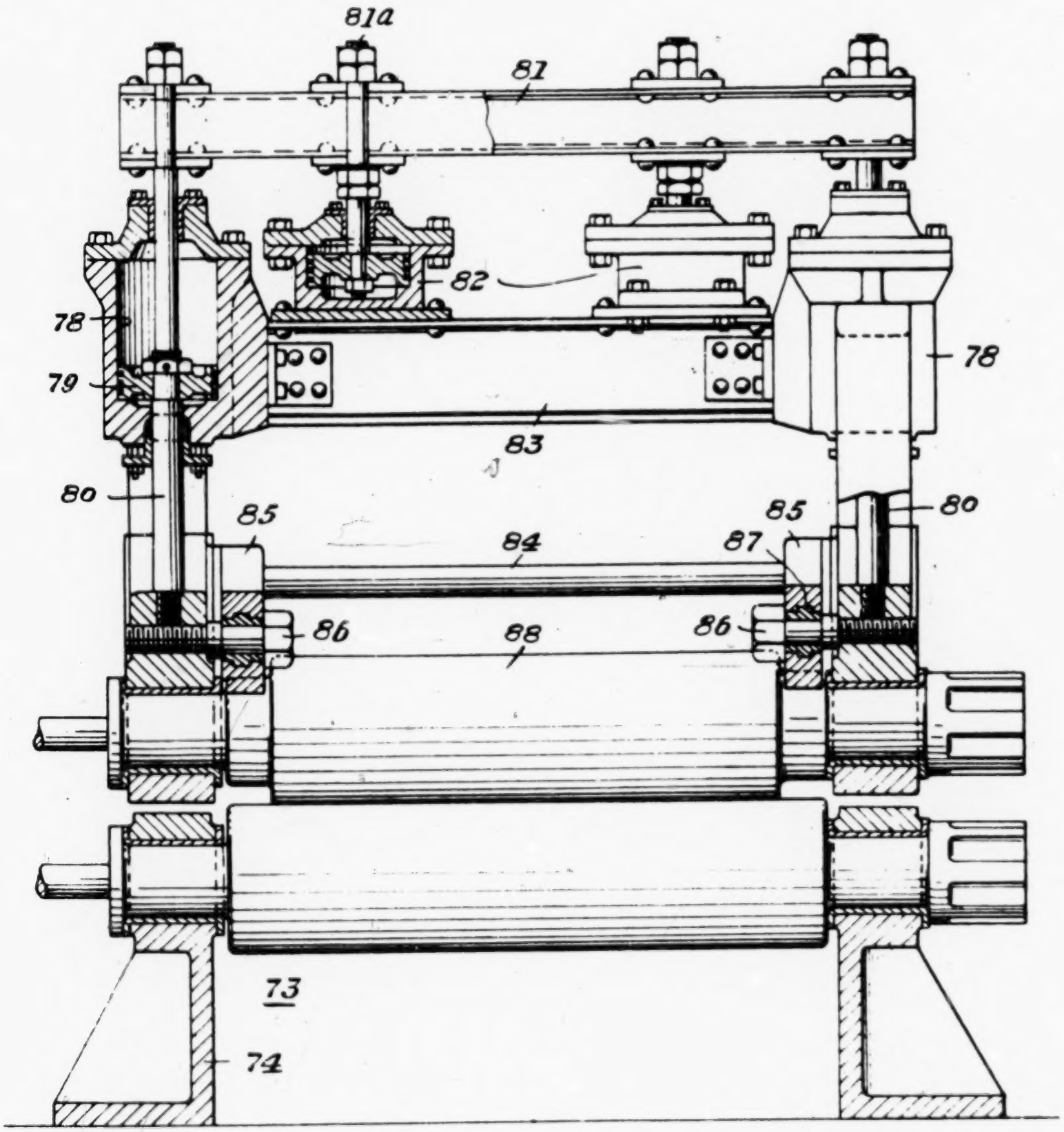
INVENTOR
Alonzo B. Montgomery
by his attorneys
Stebbins Blenko & Parmelee

Sept. 10, 1940. A. B. MONTGOMERY 2,214,107

METHOD OF ROLLING

Filed Oct. 23, 1936 6 Sheets-Sheet 5

Fig. 6.



INVENTOR
Alonzo B. Montgomery
by his attorneys
Stebbins Blanke & Parmelee

Sept. 10, 1940. A. B. MONTGOMERY 2,214,107

METHOD OF ROLLING

Filed Oct. 23, 1936 6 Sheets-Sheet 6

Fig. 8.

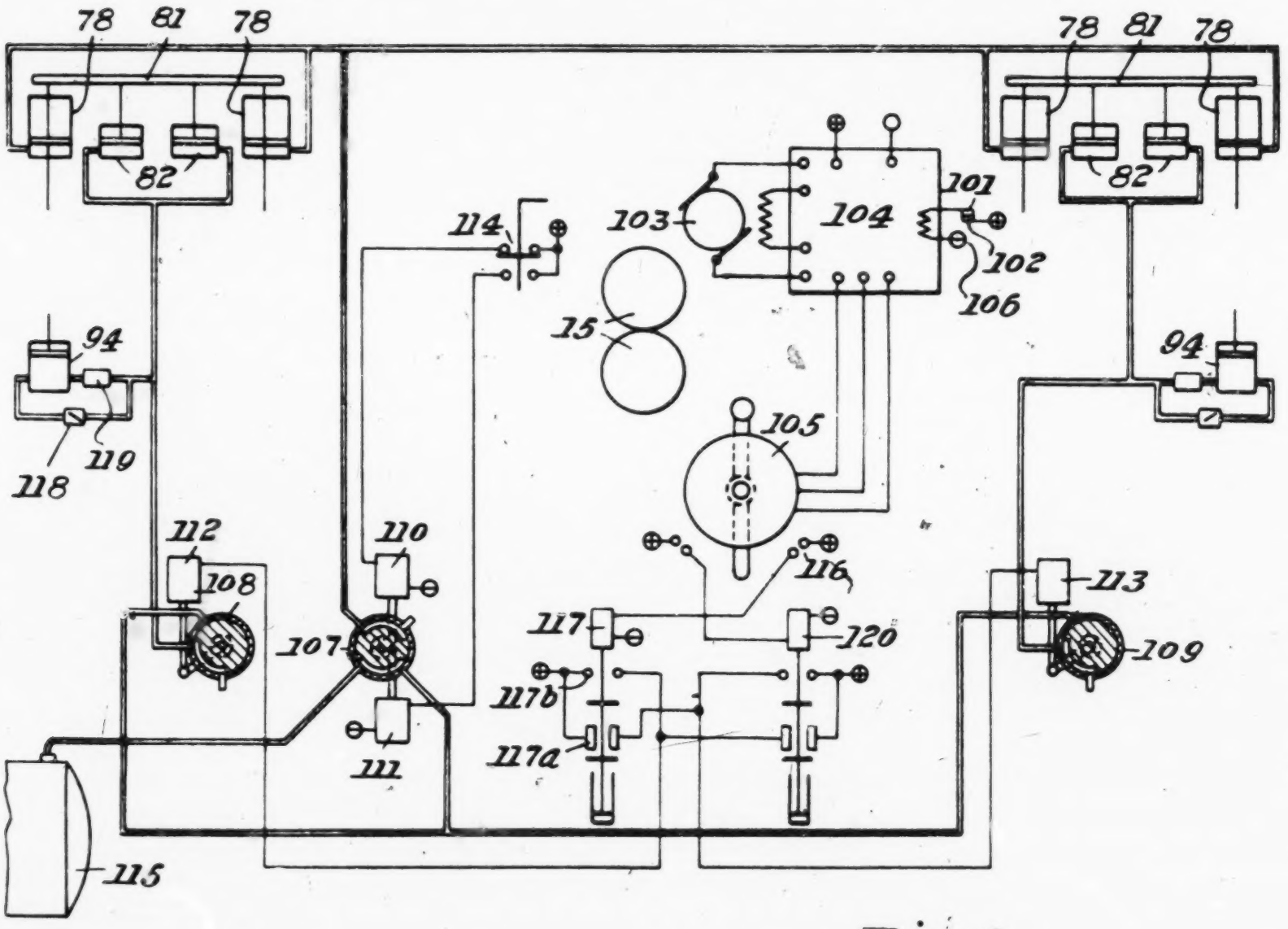
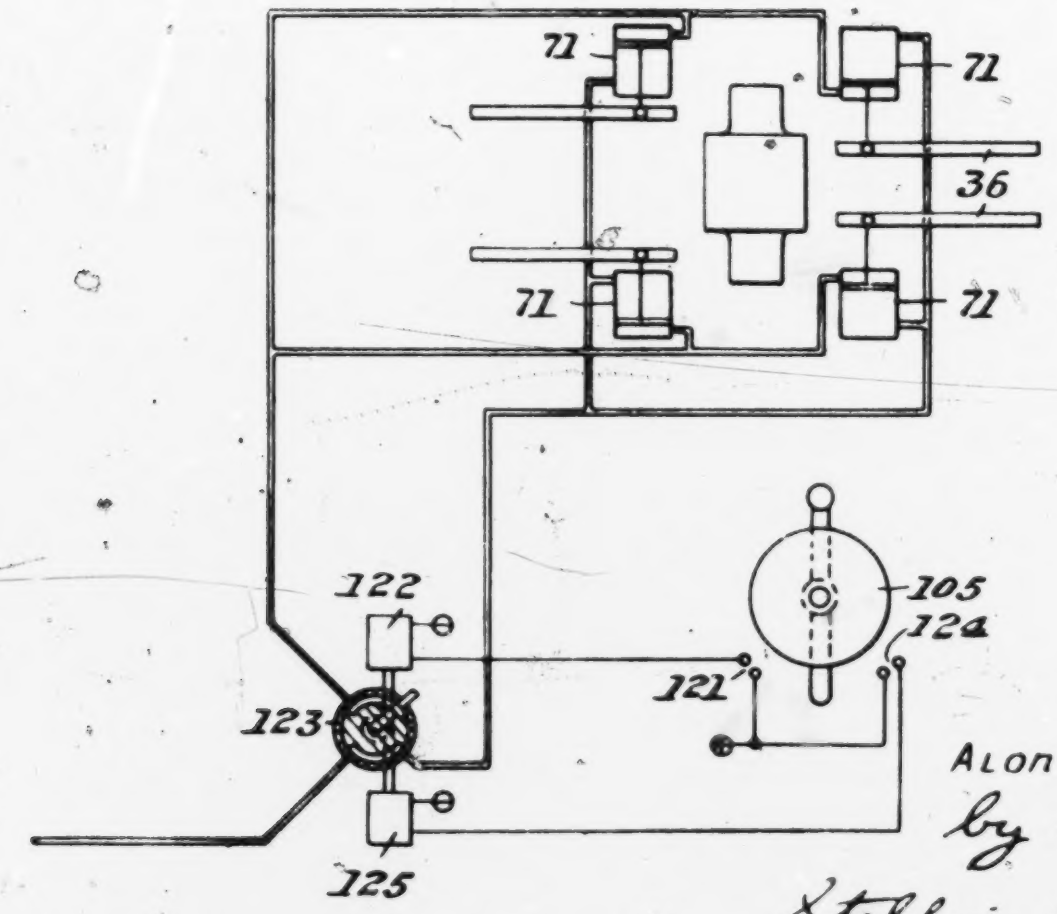


Fig. 9.



INVENTOR
Alonzo B. Montgomery
by his attorneys
Stebbins Blenko & Burnett

Patented Sept. 10, 1940 2,214,107

UNITED STATES PATENT OFFICE

2,214,107

METHOD OF ROLLING

Jonzo B. Montgomery, Youngstown, Ohio, assignor to The Cold Metal Process Company, Youngstown, Ohio, a corporation of Ohio

Application October 23, 1936, Serial No. 107,193

10 Claims. (Cl. 80—60)

This invention relates to the rolling of metal and particularly to the hot rolling of strip. The hot rolling of strip, by passing a breakdown repeatedly back and forth through a single-stand mill, has been contemplated for many years. It is only recently, however, that any progress has been made in applying this idea in actual practice.

When it was first attempted to roll strip in a single-stand mill with coiling furnaces on both sides thereon, the unwinding reel was retarded to prevent over-running thereof. The principal difficulty with early single-stand strip mills, however, was that they were incapable of consistently rolling a breakdown without camber or longitudinal curvature. This made it necessary to permit the breakdown to coil as it would, loosely, on the winding reel. Because of the looseness of the coil on the winding reel, "skidding" or axial shifting of the turns on the coil being wound up occurred with the result that on the next pass, the back tension imparted to the breakdown by the retarding of the unwinding reel caused one edge or the other to strike the side guides which were employed. This caused the edge of the strip to be folded over into a double thickness.

In my co-pending Patent 2,072,121, for Method and apparatus for guiding material, I have described and claimed a method and apparatus for guiding a slab and the breakdown rolled therefrom so that the latter, when finished, is free from camber. The present invention is useful particularly in conjunction with that of the application aforementioned.

In my copending Patent 2,072,122, I have described and claimed a mill which is an improvement over those of the types shown in United States patents to Keeney et al. No. 1,918,968 and Steckel No. 1,977,214, including guides on both sides of the mill which, while operating on the principle described and claimed in the first mentioned copending application represent a structural improvement over the latter. Beyond the guides, pinch-rolls are disposed and coiling reels are mounted within heating furnaces, in the general manner shown in the patents referred to. In accordance with the present invention, however, I utilize the pinch-rolls only while starting the leading end of a breakdown through the mill and into the coiling reel on the opposite side, the pinch-rolls being thereafter retracted, freeing the strip between the mill and the reel. I then apply sufficient torque to the shaft of the winding reel to tension the portion of the breakdown between the reel and the mill. I also apply a back tension to the portion of the breakdown between the mill and the unwinding reel thereby exerting a retarding torque on the shaft of the latter. By thus tensioning the breakdown, I am able to form a tight coil on the winding reel, thus eliminating "skidding" and preventing cambering of the product during the later rolling passes.

The guides on the exit side of the mill prevent cambering of the leading end of the breakdown until the latter is engaged by the pinch-rolls. The pinch-rolls prevent cambering of the end until the latter is engaged by the coiling reel. With the accurate start thus obtained, correct coiling of the breakdown is assured when the pinch-rolls have been retracted and the guides have ceased to have any effect because of the engagement of the end by the reel. The guides will, however, correct any incipient camber which may appear before the leading end has entered the pinch-rolls. The forward tension, furthermore, will pull out any camber which the mill tends to produce in the breakdown, after the latter has been started on the reel; and the same is true of any camber produced between the pinch-rolls and the reel. So long as the breakdown is free between the mill and coiling reel, it may be controlled by the side guides.

I drive the coiling reel so that at the point where the breakdown enters the reel is moving in a direction opposite that of the strip.

The method of my invention may be best explained by describing a preferred form of the apparatus for carrying it out. This apparatus which is also described and claimed in my Patent 2,072,122, is shown in detail in the accompanying drawings. In the drawings:

Figure 1 is a horizontal section through a mill having my invention incorporated therein showing parts in plan;

Figure 1A is a partial, sectional view similar to Figure 1 showing a slightly modified form of construction;

Figure 2 is a partial side elevation with the mill housings removed for the sake of clearness;

Figure 3 is a partial sectional view along the line III—III of Figure 2, showing parts in elevation;

Figure 4 is a partial, vertical section through the coiling furnace showing other parts in elevation to a slightly enlarged scale;

Figure 5 is a side elevation similar to Figure 4 showing a modified form of construction embodying pinch-rolls particularly adapted for automatic operation, as well as flattening rolls;

Figure 6 is a vertical, sectional view along the

line VI—VI of Figure 5 showing parts in elevation;

Figure 7 is a partial, sectional view along the line VII—VII of Figure 5;

Figure 8 is a schematic diagram of the automatic control system for the apparatus of Figures 5 through 7;

Figure 9 is a similar view of the system for controlling the guides of Figures 1 through 3;

Figure 10 is a diagrammatic plan view of the mill and the driving motors therefor; and

Figure 11 is a side elevation corresponding to Figure 10.

Referring in detail to the drawings, a mill 10 comprises housings 11 having windows 12 for receiving bearing chucks adjustably positioned therein. Backing rolls 14 and working rolls 15 are journaled in the chucks, the rolls preferably having anti-friction bearings, not shown. The housings 11 are connected by transoms 16.

Auxiliary housings 18 are positioned on opposite sides of the mill. Roll tables 19 extend between the housings 18 for conveying material to and from the mill rolls. Furnaces 20 having coilers 21 therein are positioned at a convenient distance from the mill. Tilting guides 22 are provided on the roll tables 19 for diverting material advancing through the mill from a horizontal path of travel into the coilers 21. These coilers are simply spools of convenient size with suitable driving and control equipment, each spool having blades 23 positioned therein, as shown in Figure 4, so that when the leading end of the strip enters one of the coilers between adjacent blades 23, the rotation of the coiler bends the strip around the leading edge of one of the blades. The remainder of the strip is then drawn around a scale-breaking roll 24 at the edge of the furnace mouth and wound up on the coiler.

The rolls 24 are driven by motors 24a (Fig. 10), the direction of rotation of the rolls being such as to aid movement of the breakdown toward the reel. This eliminates any drag on the breakdown which might tend to prevent a positive engagement with the reel. As shown in Fig. 4, the coiling reel is driven in a direction such that the blades on the lower side move in a direction opposite that in which the strip moves.

A base 25 is carried between each of the auxiliary housings 18. Bottom guides 26 are pivotally supported on the bases 25 at 27. The guides 26 are also supported by flat seats 28.

Top guides 29 are pivoted at 30 to the transoms 16 and are suspended from angle bars 31 extending across the mill between the chucks 13 for the top backing rolls, by links 32. The inner ends of the guides 26 and 29 are shaped to conform closely to and are actually in contact with the work rolls to effect a stripping action in case the piece tends to follow around the periphery of one or the other of the rolls.

In the subsequent description of the invention, I shall refer specifically to the equipment on the right-hand side of the mill only, as shown in Figures 1, 2 and 4, but it will be understood that duplicate equipment is employed on the opposite side of the mill.

Screw shafts 33 are slidably mounted in the housing 18 parallel to the axes of the mill rolls. Side guides 34 are supported on the screw shafts 33 by hinged joints 35. The guides 34 have a plane inner surface 36 with recesses into which anti-friction rolls 37 are let. The mill ends of the guides extend to a point closely adjacent the rolls, as shown in Figures 1 and 2. The outer ends of the guides are pivotally supported on nuts 38 traveling on a screw shaft 39 journaled in the side frames of the table 19. The ends of the screw shaft 39 are oppositely threaded so that on rotation of the shaft, the outer ends of the guides are moved toward or away from the center line of the table 19.

From what has been said, it will be apparent that my invention provides side guides which may be disposed in parallel relation, as shown on the left-hand side of the mill in Figure 1, or in angular relation, as shown on the right-hand side of the mill in Figure 1, for the purposes, respectively, of definitely and positively guiding the leading end of an advancing strip into the rolls at the proper angle thereto, and providing a tapering throat for receiving the end of the piece as it emerges from the mill. I shall now describe the mechanism for operating the guide supports to bring about the proper relation of the guides at the proper time.

The outer ends of the guides may be adjusted toward or away from each other through the shaft 39, as already described. This adjustment is effected by a hand wheel 40 having a pinion 41 meshing with a gear 42 along the screw shaft 39. A suitable pedestal bearing 43 is provided for the hand wheel shaft 44. The outer ends of the guides 34 are adjusted manually to the proper spacing before commencing the rolling.

The adjustment of the inner ends of the guides 34 is effected through the screw shafts 33. Gear cases 45 attached to the housings 18 enclose gear wheels 46 having their bores threaded for engagement with the shafts 33, and pinions 47 keyed to shafts 48. Hand wheels 49 permit manual adjustment of the screw shafts 33. These shafts are normally driven from extensions 50 of the shaft of one of the rolls 51 of the table 19. The rolls of the table are driven from a line shaft 52 through the usual bevel gears by a reversing motor, not shown. Between the shaft extensions 50 and the shafts 48 are positioned friction clutches 53 and jaw clutches 54 having operating levers 55. The purpose of the friction clutches is to permit the rotation of the shaft 48 to be arrested after a predetermined movement thereof without stopping the operation of the roll 51. The jaw clutches 54 permit the shafts 33 to be freed from the table drive while being manually adjusted.

The friction clutches 53 have detents 56 thereon cooperating with stops 57 on the housings 18 to limit rotation of the shaft 48 to the desired extent. After the detents engage the stops, the adjustment of the shafts 33 ceases but the roll 51 continues rotating with accompanying slippage of the clutches 53.

It will now be apparent that once the outer ends of the guides 34 have been adjusted, the inner ends of the guides will be spread to form a tapering throat or moved together to parallel position with the reversal of the drive for the rolls of table 19. The detents and stops controlling the amount of rotation of the friction clutches will determine the amount of movement imparted to the inner ends of the guides and may, if desired, be made adjustable. It will be understood, of course, that the guide-operating mechanism is designed so that the guides will be spread at the mill end when the table rolls are driven in such a direction as to move material away from the mill. At the same time, the guides on the opposite side of the mill will be actuated to parallel position. In this way, the material

advancing toward the mill is definitely and positively alined at right angles to the plane containing the axes of the mill rolls. The emerging material is in no wise obstructed but is gently received within a slightly tapering guiding throat. In both cases, the anti-friction rolls 37 prevent binding and insure continuous, steady forward movement of the material without grabbing or slipping. As before stated, the extreme positions of the inner ends of the guides may be adjusted initially by hand after disengaging the clutches 54. Thereafter, the range of movement of the inner ends of the guides is determined by the location of the detents 56 and stops 57. In the construction illustrated, I have assumed that one complete revolution of the shaft 50 will produce the necessary movement of the inner ends of the guides.

Referring now particularly to Figure 4 for a disclosure of the flattening rolls, housings 60 supported on side members of the roll table 19 have bearing chucks 61 movable vertically therein by means of a pneumatic cylinder 62. Rolls 63 and 64 journaled in the chucks 61 cooperate with adjacent rolls 65 of the table 19. A roll 66 also journaled in the chuck 61 cooperates with a roll 67 journaled in adjustable chucks 68. The chucks 68 are actuated by pneumatic cylinders 69.

The rolls 63 and 65 may be driven and when the former is lowered into engagement with the latter, they serve as pinch rolls to feed the strip toward the mill from the coiler 21. When the strip has been started through the mill and engaged the coiler on the opposite side thereof, the chucks 61 are preferably raised and the rolls 63, 64 and 66 lifted off the strip. The chucks 68 of the rolls 67 are preferably lifted at the same time as the chucks 61. In its normal lower position, however, the roll 67 is effective to assist in flattening or leveling the leading end of the material in its passage from the mill to the coiler. The pinch rolls 63 are lowered, of course, at this time. If the leading end, after passing through the pinch rolls, is deflected downward, it will engage the roll 67 and then the roll 65. On passing between the rolls 64 and 65, the end will be flattened sufficiently to engage the coiler 21 without difficulty. Similar results occur if the leading end of the piece is deflected upward, in which case it wil engage the rolls 66 and 64 successively, and after passing between the roll 64 and the roll 65 cooperating therewith, will be found to be satisfactorily flattened. The control of the fluid supplied to the cylinders 62 and 69 has not been illustrated since it may be of any desired character, automatic or manual.

Figure 1A illustrates a modified form of actuating mechanism for the guides 36. This means takes the form of pistons 70 reciprocable in cylinders 71 by means of fluid pressure, hydraulic or pneumatic, supplied thereto. The pistons 70 have piston rods 72 attached thereto corresponding to the screw shafts 33 and functioning in the same way, under the influence of fluid pressure admitted to either side of the cylinders 71 for actuating the guides.

A modified form of construction of the auxiliary rolls for feeding and flattening the strip is shown in Figures 5 through 7. A roll table 73 has side frame castings 74. Housings 75 are attached to the castings 74 and have windows 76 therein in which bearing chucks 77 are slidable. Cylinders 78 formed in the upper part of the housings 75 have pistons 79 reciprocating therein. Piston rods 80 attached to the pistons 79 are threaded into the chucks 77 whereby the latter may be lifted to the dotted line position shown in Figure 5. Piston rods 80 extend outwardly through the upper end of the cylinders 78 and are connected by cross beams 81. Cylinders 82 carried on a transom 83 extending between the housings, also have pistons and piston rods arranged as shown in Figure 6 whereby the beams 81 and, therefore, the chucks 77, may be raised through a small distance. The piston rods of the cylinders 82 have separable, abutting engagement with bolts 81*a*. It will be apparent that the cylinders 78 and 82 provide independent means for lifting the chucks 77 through a long stroke and a short stroke, respectively. The object of this arrangement will become apparent as the description proceeds.

An equalizing shaft 84 extends between the housings 75 and is journaled therein. Cranks 85 keyed to the shaft 84 carry trunnions 86 in slidable bearing blocks 87. The trunnions 86 are threaded into the chucks 77, as best shown in Figure 6. The equalizing shaft obviously serves to effect simultaneous and equal movement of both bearing chucks and prevents binding of the reciprocating mechanism.

A top pinch roll 88 is journaled in the chucks 77 for cooperation with a bottom pinch roll 89, which may conveniently be one of the rollers of the table 73. Flattening rolls 90 and 91 are also journaled in the chucks 77. The roll 91 cooperates with a roll of the table 73. A roll 92 is journalled in chucks 93 slidable vertically in the base portions of the housings 75. Cylinders and pistons 94, bell crank linkage 95 and struts 96 are provided, as shown in Figure 5 to effect vertical movement of the chucks 93 for a purpose which will appear later.

As best shown in Figure 7, the roll 90 is journaled in chucks 97 secured to the chucks 77. A contact-actuating rod 98 is threaded into a projection 99 from one of the chucks 93. The rod 98 also passes through guides 100 projecting from one of the chucks 97. The rod 98 controls the engagement of a moving contact 101 with a fixed contact 102 on one of the chucks 77 for a purpose which will presently appear.

The chucks 93 are normally lowered so that contact 101 engages contact 102. These contacts control a circuit for stopping the main mill motor in case of breakage of the strip. When the strip is being rolled, the rolls 88, 90 and 91 rest on the strip and are spaced thereby from the rolls 89 and 92. After the strip has been entered into the mill so as to separate the pinch rolls 88 and 89, fluid is admitted to the cylinders 94 to cause the chucks 93 to be raised until the roll 92 engages the lower surface of the strip. The rolling operation then proceeds. If breakage of the strip should occur, the continuing fluid pressure in the cylinders 94 causes the chucks 93 to rise until the roll 92 actually engages the roll 90. This causes the rod 98 to move upwardly and lift contact 101 out of engagement with contact 102. Separation of these contacts, through suitable auxiliary equipment, causes stoppage of the main mill motor.

The cylinders 79 and 82 are automatically controlled to cause the pinch rolls 88 and 89 to engage the material at certain times and to release it at other times.

In rolling a slab into strip on the mill 10, it is desirable that the pinch rolls 88 be withdrawn as long as the slab being reduced has sufficient rigidity to permit it to be fed back and forth to

and from the mill by the friction of the table rolls. When the slab has been reduced to a gauge such that it has relatively little rigidity, or to a condition in which coiling between passes is advisable, the pinch rolls are advanced to assist in threading the strip through the mill at the beginning of each pass. While both ends of the strip actually pass through the mill, the pinch roll motors are so controlled that neither end of the strip is disengaged from the pinch rolls on both sides of the mill. At least one end of the strip is always engaged by at least one set of pinch rolls. It is by these pinch rolls that the strip is then fed back to the mill for the next pass. On the exit side of the mill, the pinch rolls assist in delivering the leading end of the strip into the coiler by pushing it up the guide 22.

The system for automatically controlling the pinch rolls will be now explained with reference to Figure 8. In Figure 8, the work rolls of the mill are indicated by the same numeral as in Figures 1 and 2. A motor 103 is provided for driving the mill and the power of the motor may be applied directly to the work rolls 15 or to the backing rolls 14. The motor 103 may be controlled by any suitable control system. For simplicity, I have only illustrated a control panel 104 having incoming power leads, outgoing motor leads, and outgoing control leads extending to a controller 105. The panel 104, of course, will be provided with suitable relays and contactors effective under the control of the controller 105 to cause starting of the motor 103. The panel 104 also has a relay 106 effective when deenergized to cause stopping of the motor. The specific details of such an arrangement are known and need not be included here. The controller 105, obviously, is effective on being shifted manually in one direction or the other, to cause operation of the motor 103 to drive the mill rolls 15 and thus move the strip through the mill in the desired direction. The supply of fluid to the cylinders 78, 82 and 94 is controlled by a master valve 107 and auxiliary valves 108 and 109. The valve 107 has operating magnets 110 and 111 and the valve is of such character that it remains in the position to which it was last operated until positively actuated therefrom. The valves 108 and 109 have operating magnets 112 and 113. The arrangement of these valves and their operating magnets is such that they remain in the illustrated position until the magnets are energized, and return to the illustrated position when the magnets are deenergized.

The valve 107 is controlled by a limit switch 114 operated by any convenient means, in accordance with the position of the mill screwdowns which determine the thickness of the pass between the rolls and the material itself after passing through the mill. When the space between the mill rolls 15 is greater than a predetermined value, say ¾", the limit switch 114 closes its lower contacts to energize the magnet 111 and move the valve 107 so that fluid under pressure is supplied from a reservoir 115 through suitable piping, to the cylinders 78 on both sides of the mill. The pistons 79 are thereby actuated full stroke to withdraw the upper pinch roll 88 and provide ample free space for the passage back and forth to and from the mill of the slab in the initial stages of its reduction to strip.

When the thickness of the slab has been reduced to a point such that, on the next pass, the mill rolls are spaced apart only ¾" or less, the partially reduced material is sufficiently thinned and elongated to permit of coiling and, at the same time, its rigidity is such that the assistance of the pinch rolls is required to manipulate it through the mill and into the coilers. The limit switch 114 then closes its upper contacts to energize the magnet 110 and operate the valve 107 to the illustrated position. This vents the cylinder 78 and the pistons 79 immediately drop to lower the pinch rolls 88 onto the material. The pinch rolls are driven by any convenient means, at the same peripheral speed as the rolls 15, so as to cooperate therewith in moving the material back and forth.

If it is assumed for the sake of explanation that the breakdown formed from flat rolling the slab was reduced on a pass from left to right, to a gauge such that after the next reduction, it would be less than ¾" thick, as soon as the top roll 15 is lowered to within less than ¾" of the bottom roll, the described operation of the valve 107 will take place and the pinch rolls will seize the breakdown for the next pass from right to left. When all is ready for this pass, the roller operates the handle of the controller 105 to the left, as shown in Figure 8, whereupon the motor 103 is operated so as to drive the rolls 15 and roll the strip from right to left. The pinch roll drive is so coordinated with that of the mill that the pinch rolls 88 are simultaneously operated so as to assist in the feeding of the breakdown.

The movement of the controller 105 bridges contacts 116 to energize a relay 117. The relay 117 has a time delay in its operation, indicated by a dashpot, and after a certain time bridges contacts 117*a* to energize the magnet 113. The relay is adjusted so that the contacts 117*a* will be bridged just after the leading end of the breakdown being rolled passes between the rolls 15. The magnet 113 operates the valve 109 to admit fluid supplied through the valve 107 to the cylinders 82 on the entering side of the mill. The pinch roll 88 on that side is thus lifted from the material.

After a slightly longer time, the relay 117 operates to bridge its contacts 117*b*, maintaining the circuit for the magnet 113 by reason of the fact that the bridging contact slides along the contacts 117*a*. The relay is adjusted so that the contacts 117*b* are bridged after the material has emerged from the mill on the exit side, passed through the pinch rolls, and made one turn about the coiler. The bridging of the contacts 117*b* causes the operation of magnet 112 to shift the valve 108. The cylinders 82 on the exit side of the mill thus operate to raise the associated pinch roll from the strip. The strip is thus free between the winding and unwinding coilers, except where engaged by the mill.

The operation of the valves 109 and 108 described above, also causes the operation of the cylinders 94 on opposite sides of the mill. The roll 92 is thus raised into engagement with the material but is sufficiently spaced thereby from the roll 90 that the contact 101 remains in engagement with the contact 102. The fluid pressure is continuously applied to the cylinders 94 as long as the rolling continues but, unless the strip breaks during rolling, the rolls 90 and 92 are maintained separated and the contacts 101 and 102 remain in engagement. If the strip is broken, the roll 92 is immediately lifted into engagement with the roll 90, whereupon the rod 98

lifts the contact 101 to open the circuit for the relay 106 and thereby stop the motor 103.

As soon as the leading end of the breakdown has been engaged by the coiling reel, and the pinch rolls retracted, I cause the motor 21a driving the coiling reel to exert thereon a torque sufficient to impart tension to the breakdown between the coiling reel and the mill. At the same time, I operate the motor 21a connected to the unwinding reel as a generator, to impart a back tension to the portion of the breakdown between the uncoiling reel and the mill. The torques exerted by the motor and generator are preferably maintained constant by any convenient means such as current regulators effective to maintain constant currents through the armatures of the motor and generator. The relationship of the regulators to the motor and generator is reversed on reversal of the mill, the regulator for the coiling-reel motor, obviously, being set for a greater current than the regulator connected to the uncoiling-reel generator.

By this provision, I tension the breakdown on the exit side of the mill between the mill and coiling-reel. On the entrance side, the breakdown is tensioned between the mill and the uncoiling-reel.

When the pass is completed, the controller 105 is restored to neutral position so that the trailing end of the strip stops between the mill and the pinch rolls on the exit side thereof. The relay 117 is thus deenergized and substantially immediately opens its contacts to deenergize magnets 112 and 113. The cylinders 82 are thus exhausted to the atmosphere and the pinch rolls dropped. At the same time, the cylinders 94 are exhausted through check valves 118, the weight of the roll 92 and chucks 93 serving to force the accumulated fluid out of the cylinders. The operating fluid for the cylinders 94 passes initially through expansion valves 119 which slightly delays the lifting of the chucks 93 on starting a pass.

The next pass is accomplished in exactly the same manner. Reversal of the controller 105 energizes the relay 120 and this, in turn, causes sequential lifting of the pinch rolls 88 on the entering and exit sides of the mill. This cycle is repeated until the strip has been reduced to the desired gauge, when it is wound on a coiler beyond the furnace on the exit side of the mill. The top work roll is then lifted by reversal of the screwdowns. The switch 114 closes its lower contacts and operates the valve 107 to admit fluid under pressure again to the cylinders 78, whereby the pinch rolls 88 on both sides of the mill are lifted out of the way for the next flat rolling operation.

Figure 9 shows how the side guide actuators of Figure 1A are controlled. When the controller 105 is shifted so as to cause the material to be fed from left to right, it closes contacts 121. It will be understood that operation of the controller also, through appropriate relays, causes the starting of the motor 103 in the proper direction. The closing of the contacts 121 energizes an operating magnet 122 for a valve 123. This valve is similar to that shown at 107 of Figure 8. The energization of the magnet 122 operates the valve to the position illustrated in Figure 9, in which it delivers fluid under pressure to the inner ends of the cylinders 71 on the exit (left-hand) side of the mill, and to the outer ends of the cylinders on the entering (right-hand) side of the mill. The guides 36 on the entering side are thus closed in, as indicated in Figure 9, while the guides on the exit side are opened to permit free passage of the material as it emerges from the mill.

On the reversal of the direction of rolling, for the next pass, the controller 105 bridges contacts 124 and energizes a magnet 125 to shift the valve 123 to the other position. The reverse operation of the cylinder 71 then takes place to close the guides on the left-hand side and open the guides on the right-hand side.

It will be understood that only a single controller 105 is employed and that it controls contacts 116 and 124, for example, simultaneously, in addition to the other contacts necessary to bring the motor 103 up to operating speed. The system of Figure 9 is shown separately from that of Figure 8 simply because it is a diagrammatic plan, whereas the latter is a diagrammatic elevation, but it will be understood that the two systems are combined and under the common control of the controller 105.

It will be apparent from the foregoing description that my invention provides a rolling mill having numerous advantages over known apparatus of the same kind. In the first place, the slab or strip is definitely guided into the mill along the pass line or longitudinal axis of the mill. There is thus no possibility for the strip to move into the rolls crabwise at a slight angle to the pass line. Cambering of the strip or slab is thus prevented. Free movement of the highly flexible, thin strip from the mill is permitted without obstruction since the guides on the exit side of the mill are automatically retracted to form a tapering guiding throat. The positions of the guides on opposite sides of the mill are reversed automatically with the reversal of the roll tables and the mill so that once the guides have been adjusted, they require no further attention until a different width of material has to be rolled.

The flattening rolls insure that the leading end of the strip will always be sufficiently flat to enter and engage the coiler properly to wind the strip thereon. This avoids the delays experienced heretofore incident to the backing up of the strip and repeating the entry thereof into the coiler after a first unsuccessful attempt.

The top and bottom guides 29 and 26 respectively, with the side guides 34, form a complete guide box and prevent any departure of the strip from the pass level or the horizontal plane through the roll pass. With the guides of my invention, improper entry of the material into the mill is rendered almost impossible. The top guide may be adjusted by a turn-buckle in the links 32. The bottom guide may be similarly adjusted by shimming up the outer end thereof which rests on the seat 28.

The automatic control of the pinch rolls on both sides of the mill insures that the strip will be advanced properly into the mill and, on emerging therefrom, into the coiler, whereupon the pinch rolls will be lifted out of the way when there is no further need for them. The automatic stop mechanism prevents loss, damage or injury in case the strip breaks during a pass.

The positive actuation of the side guides under the control of the main controller causes the strip to be properly started toward the mill and correctly positioned with respect thereto before it actually enters between the mill rolls, after which no effort is sufficient to correct an improper starting of the strip, because of the great force exerted on the strip by the rolls.

The top guide 29 has an important function in

preventing the coiling up of the leading end of the piece when rolling in the flat. If it were not for this guide, the slab, in the early stages of its reduction, might bend up sufficiently to escape the side guides altogether, whereupon it might be improperly entered into the mill pass on the next reversal.

By tensioning the portion of the breakdown between the mill and the coiling reel, I cause the material to coil tightly and accurately on the coiling reel, thus avoiding skidding and possible deformation of the edge of the breakdown on the next pass. The tension also serves to remove any camber which might be rolled into the strip by the mill. By raising the pinch rolls after starting the piece through the mill, I avoid introducing camber into the material as a result of the reduction caused by the pinch rolls. The guides serve to correct camber of the leading end of the piece while it is free. The pinch rolls tend to prevent the introduction of the camber before the piece is started on the reel. Thereafter, the forward tension prevents cambering at a time when the guides are comparatively ineffective. If the material departs from the center line of the mill while the pinch rolls engage it, this departure will be corrected as soon as the pinch rolls are raised and forward tension is applied.

By driving the coiling reel in a direction such that the point where it is engaged by the leading end of the breakdown is traveling in a direction opposite that of the latter; I ensure positive engagement by hooking the end of the piece around the leading edge of one of the reel plates.

Although I have illustrated and described only one embodiment of my invention, it will be apparent that numerous changes therein may be made without departing from the spirit of the invention or the scope of the appended claims.

I claim:

1. In a method of hot rolling a breakdown into strip by passing it back and forth through a mill having pinch rolls on both sides thereof and coiling reels beyond the pinch rolls, the steps including causing the pinch rolls on one side of the mill to engage the trailing end of a breakdown coiled on the reel on that side of the mill, driving last mentioned pinch rolls to feed said end back to the mill, driving the pinch rolls on the other side while maintaining them in gripping engagement with the breakdown to feed said end toward the other reel, and retracting at least one of each set of pinch rolls to free the breakdown between the mill and the reels during the remainder of the pass.

2. The method defined by claim 1 characterized by so driving the winding reel as to tension that portion of the breakdown between it and the mill.

3. The method defined by claim 1 characterized by so retarding the unwinding reel as to tension that portion of the breakdown between it and the mill.

4. In a method of converting a slab or ingot into strip, the steps including passing a slab back and forth in the flat between reducing rolls to form a breakdown, passing the breakdown back and forth between reducing rolls to form a strip, winding the breakdown on a coiling reel between passes through the rolls, bending the breakdown about a guide roll, and driving said guide roll to prevent frictional drag on the breakdown.

5. The method defined by claim 1 characterized by retracting one of each set of pinch rolls a greater distance before starting the rolling of a breakdown into a strip, while rolling the breakdown from a slab or ingot without coiling.

6. In a method of rolling strip, the steps including passing a breakdown, heated to plastic condition, back and forth between reducing rolls, uncoiling it on one side and coiling it on the opposite side of the rolls, passing an end of the breakdown entirely through the rolls, frictionally gripping said end to feed it back through the rolls, freeing that portion of the breakdown between the mill and the point of coiling, and tensioning such portion uniformly throughout.

7. In a method of making strip by passing a breakdown, heated to plastic condition, through reducing rolls, coiling the strip on the exit side, uncoiling it from a previously formed coil on the entrance side of the rolls, gripping the strip at points between the rolls and points of coiling only long enough at the beginning of each pass to thread the end of the breakdown through the rolls and start coiling thereof on the exit side, and then freeing the breakdown between the rolls and the points of coiling, while continuing to pass the strip through the mill in the same direction.

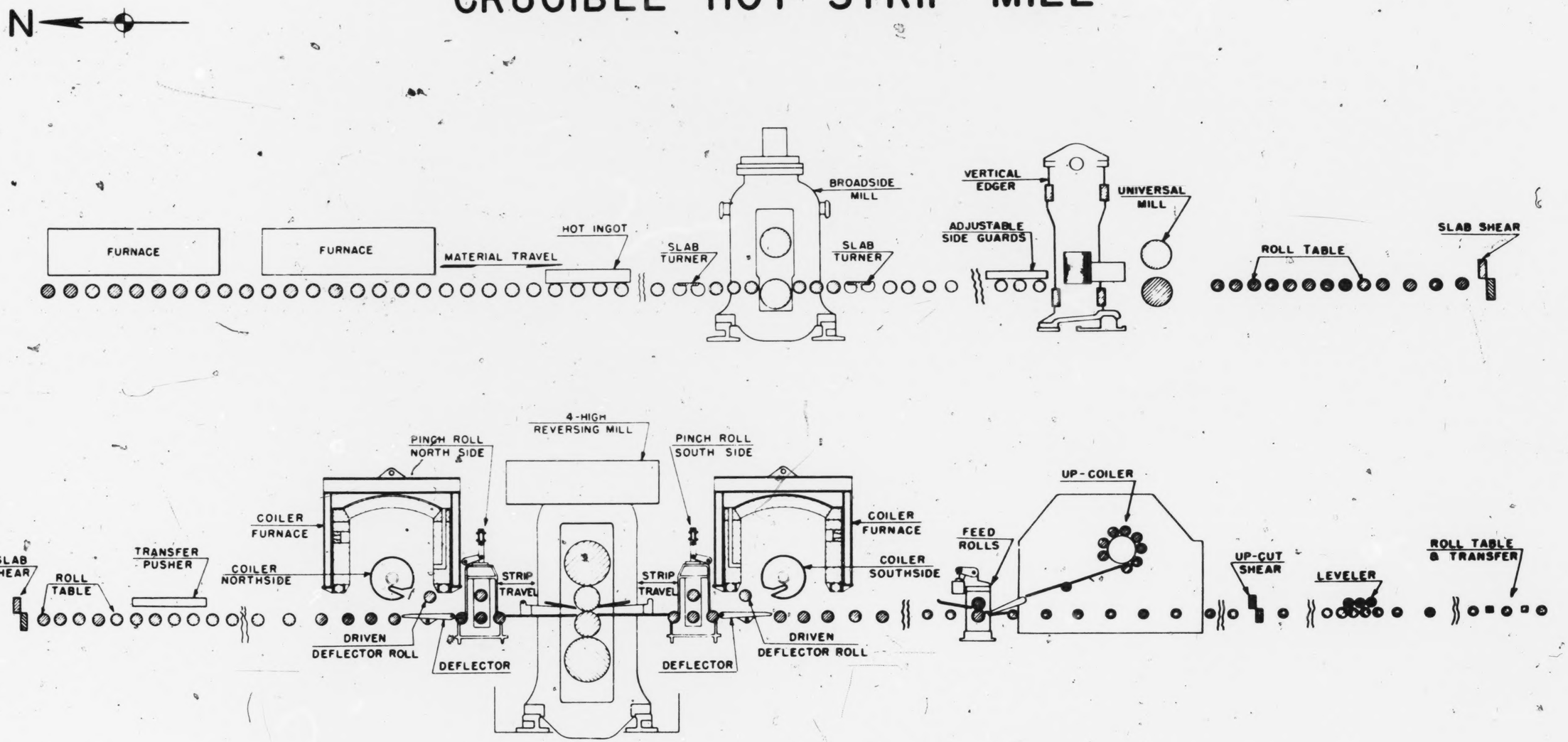
8. The method defined by claim 7 characterized by tensioning the portion of the breakdown between the rolls and the point of coiling uniformly throughout to cause the breakdown to coil straight and true.

9. In a method of rolling strip, the steps including passing a breakdown back and forth between reducing rolls, coiling the breakdown on one side of the mill between passes, frictionally engaging the outer end of the coil to drive it back toward the mill between parallel edge guides, receiving said end as it emerges from the mill between converging edge guides, frictionally engaging said end to drive it toward the point of coiling on the exit side of the mill, and freeing the portions of the breakdown inwardly of the edges thereof and between the mill and the points of coiling from frictional driving or retarding engagement.

10. The method defined by claim 9 characterized by coiling the breakdown emerging from the mill under torque sufficient to tension uniformly that portion of the breakdown between the mill and point of coiling to cause it to wrap true in a coil.

ALONZO B. MONTGOMERY.

CRUCIBLE HOT STRIP MILL



DIAGRAMMATIC SECTION OF COMPLETE MILL

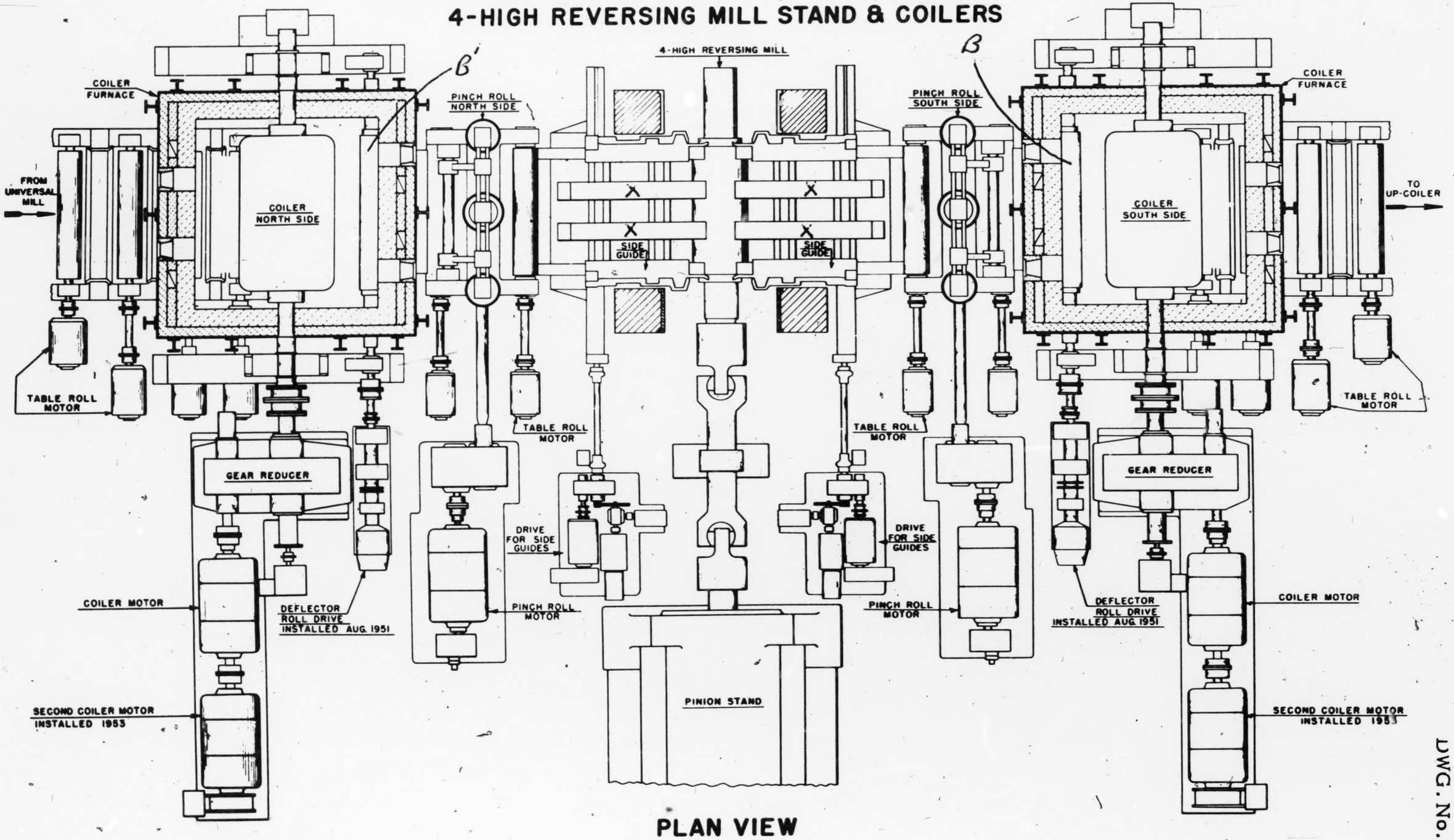
Plaintiff's Exhibit P-16.

131a

DWG. No. 1

CRUCIBLE HOT STRIP MILL

4-HIGH REVERSING MILL STAND & COILERS

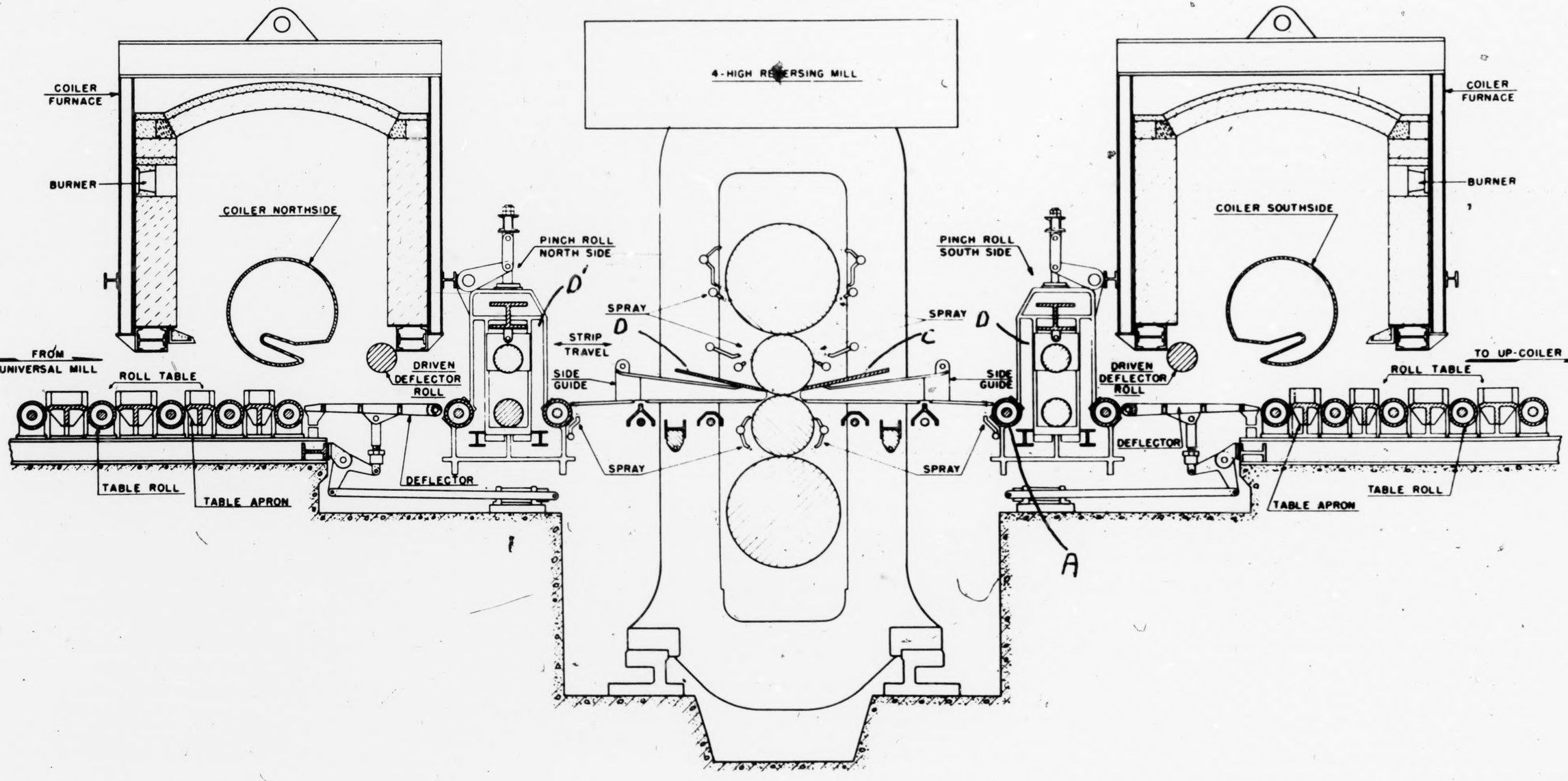


PLAN VIEW

133a
DWG. No. 2

CRUCIBLE HOT STRIP MILL

4-HIGH REVERSING MILL STAND & COILERS

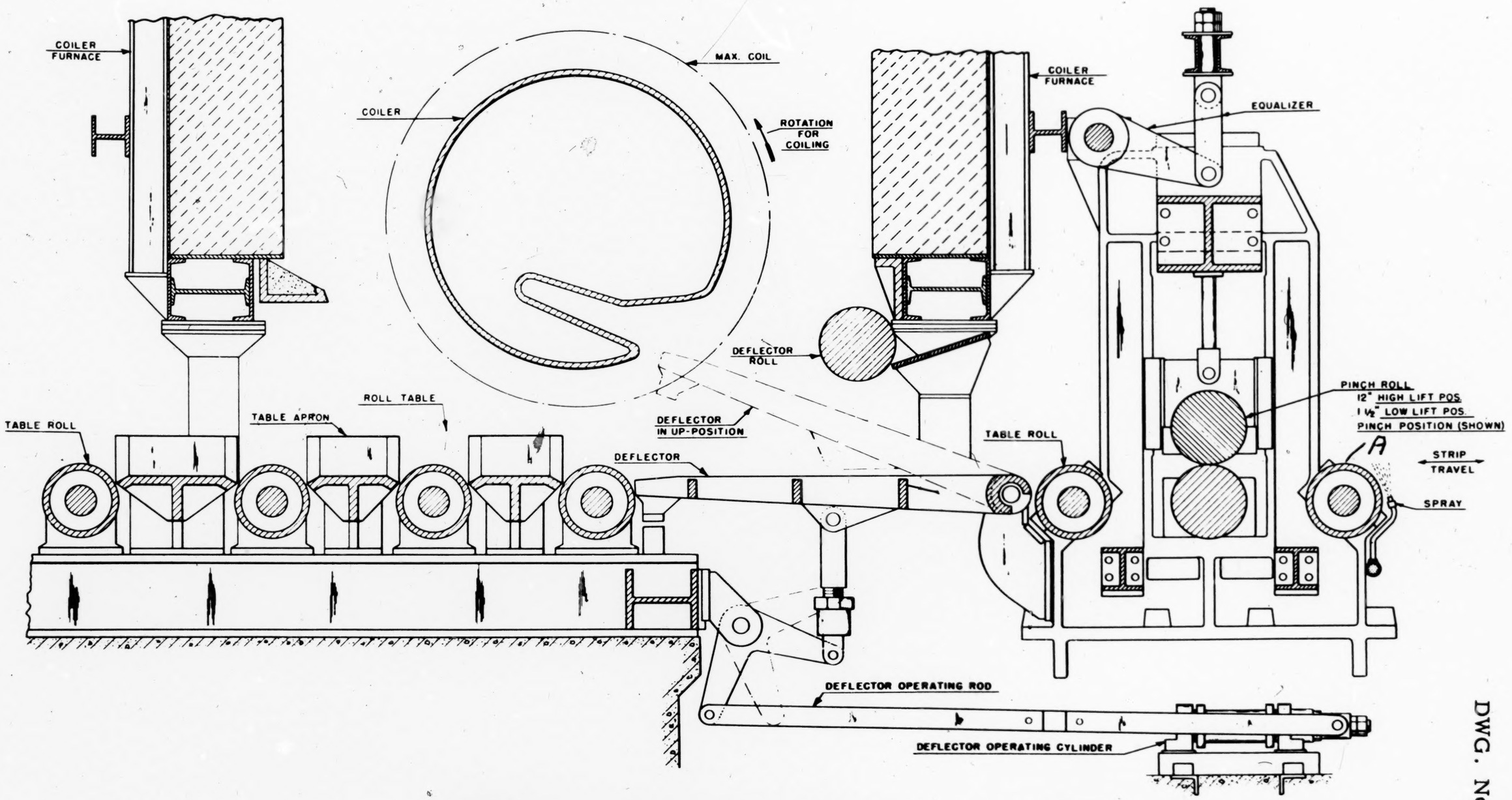


VERTICAL SECTION

DWG. No. 3

135a

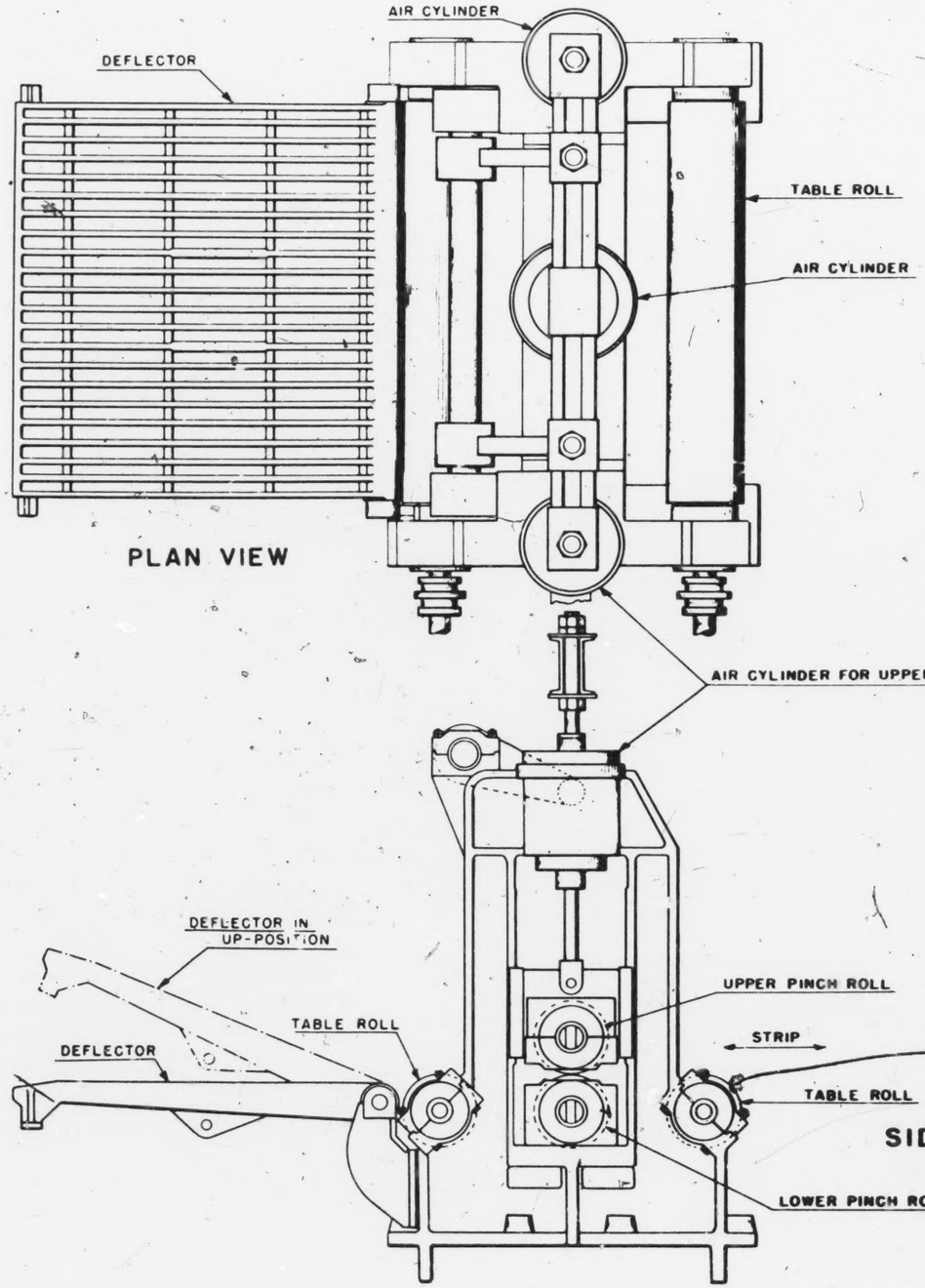
CRUCIBLE HOT STRIP MILL



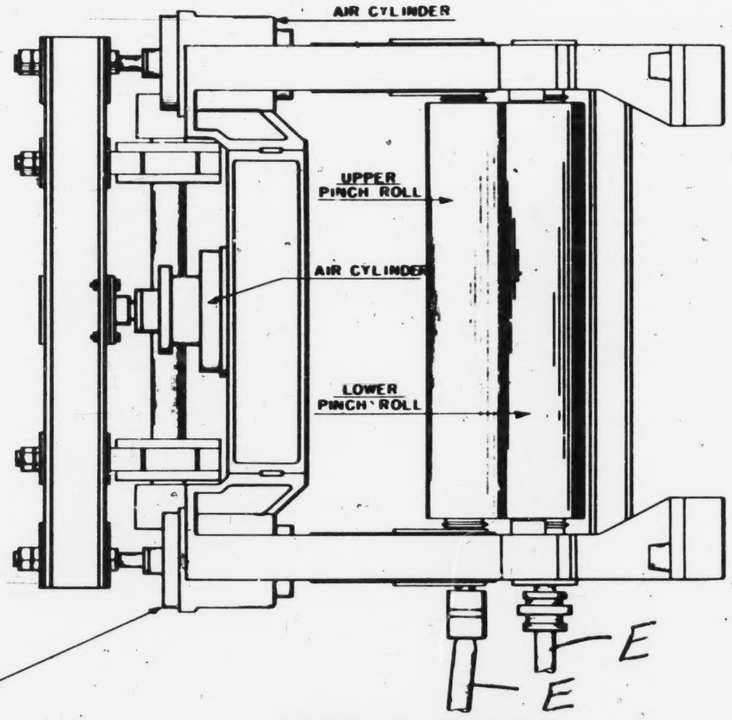
VERTICAL SECTION AT PINCH ROLL & COILER

DWG. No. 4

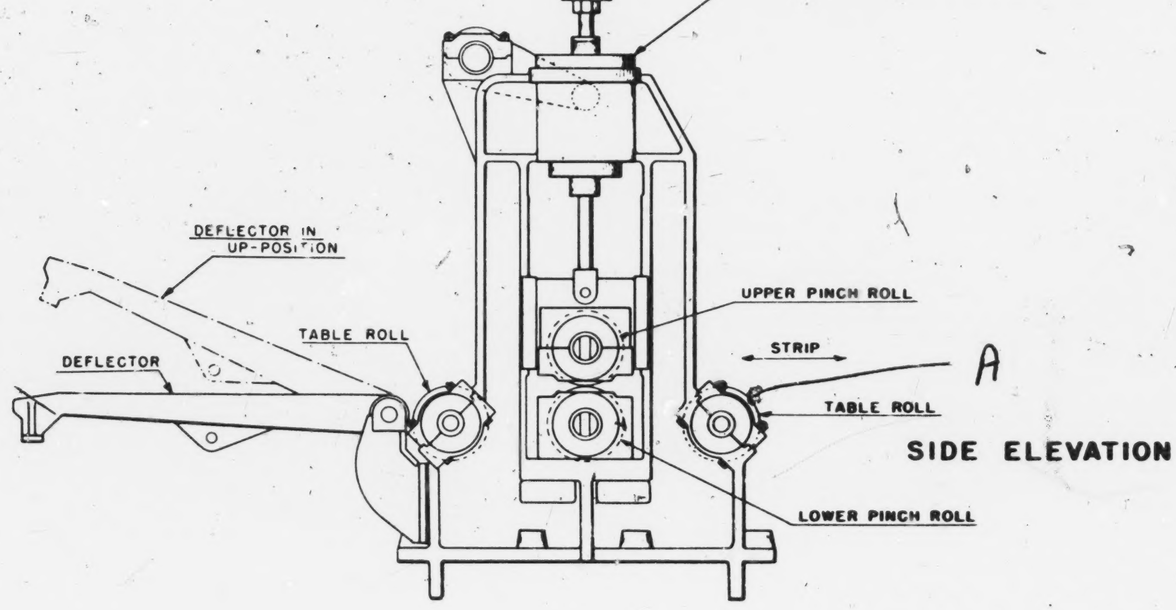
CRUCIBLE HOT STRIP MILL



PLAN VIEW



FRONT ELEVATION



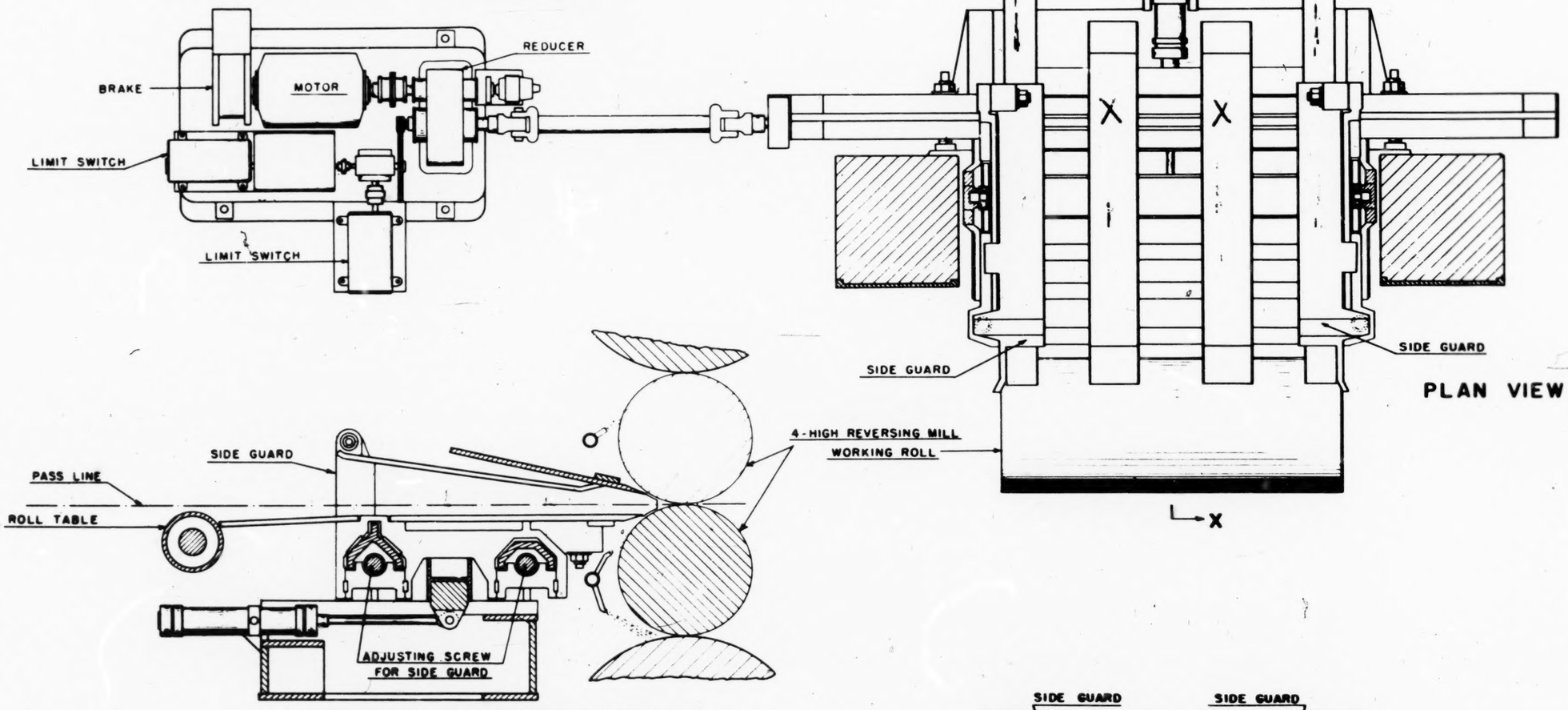
SIDE ELEVATION

DEFLECTOR AND PINCH ROLL ASSEMBLY

139a.
DWG. No. 5

CRUCIBLE HOT STRIP MILL

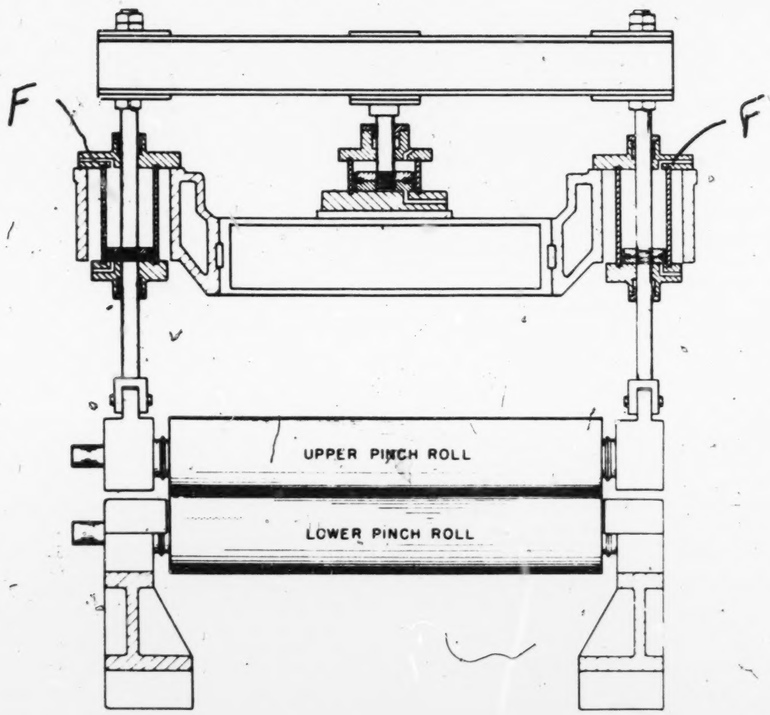
SIDE GUIDE ASSEMBLY



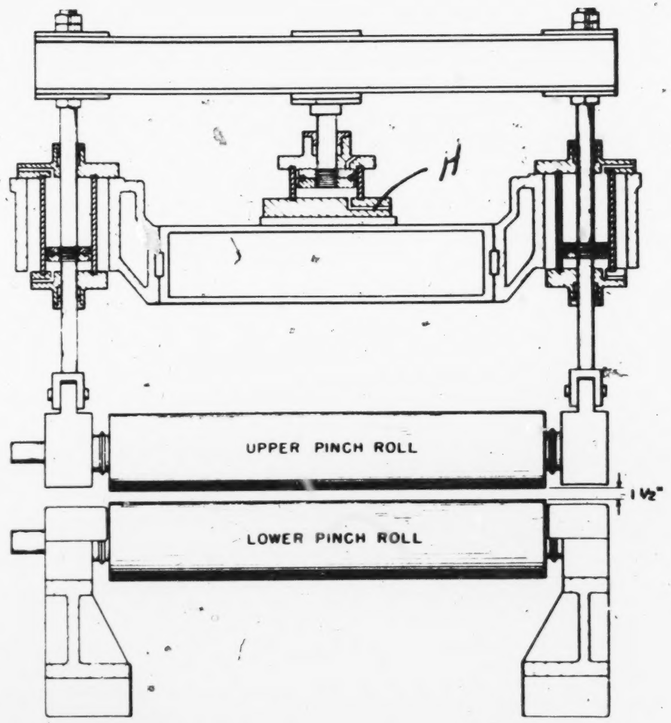
141a
DWG. No. 6

CRUCIBLE HOT STRIP MILL

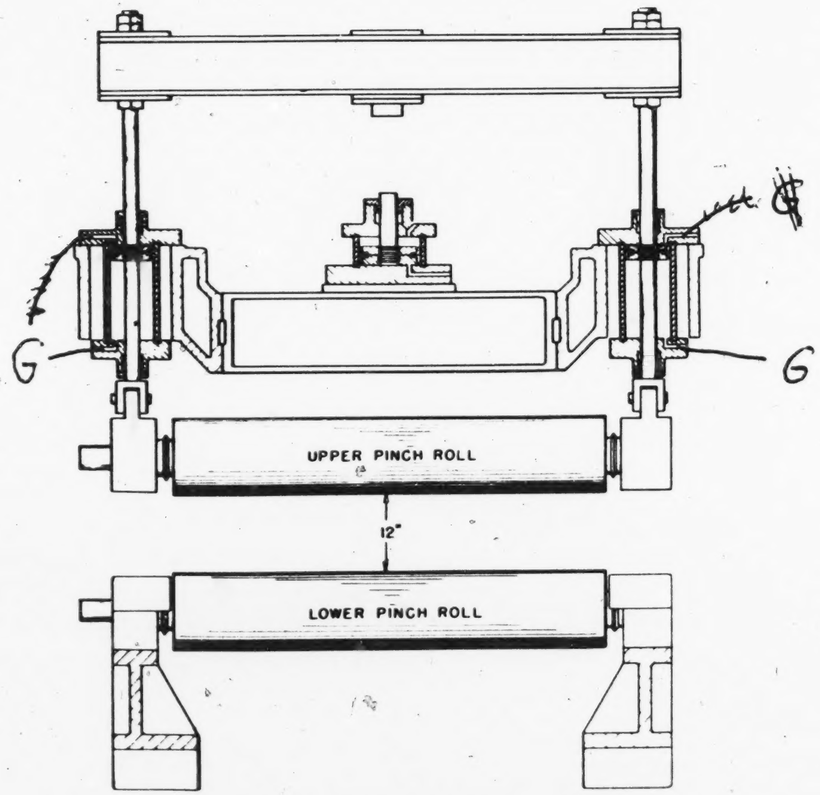
PINCH ROLL OPERATION



PINCH POSITION



LOW LIFT POSITION



HIGH LIFT POSITION

LEGEND:

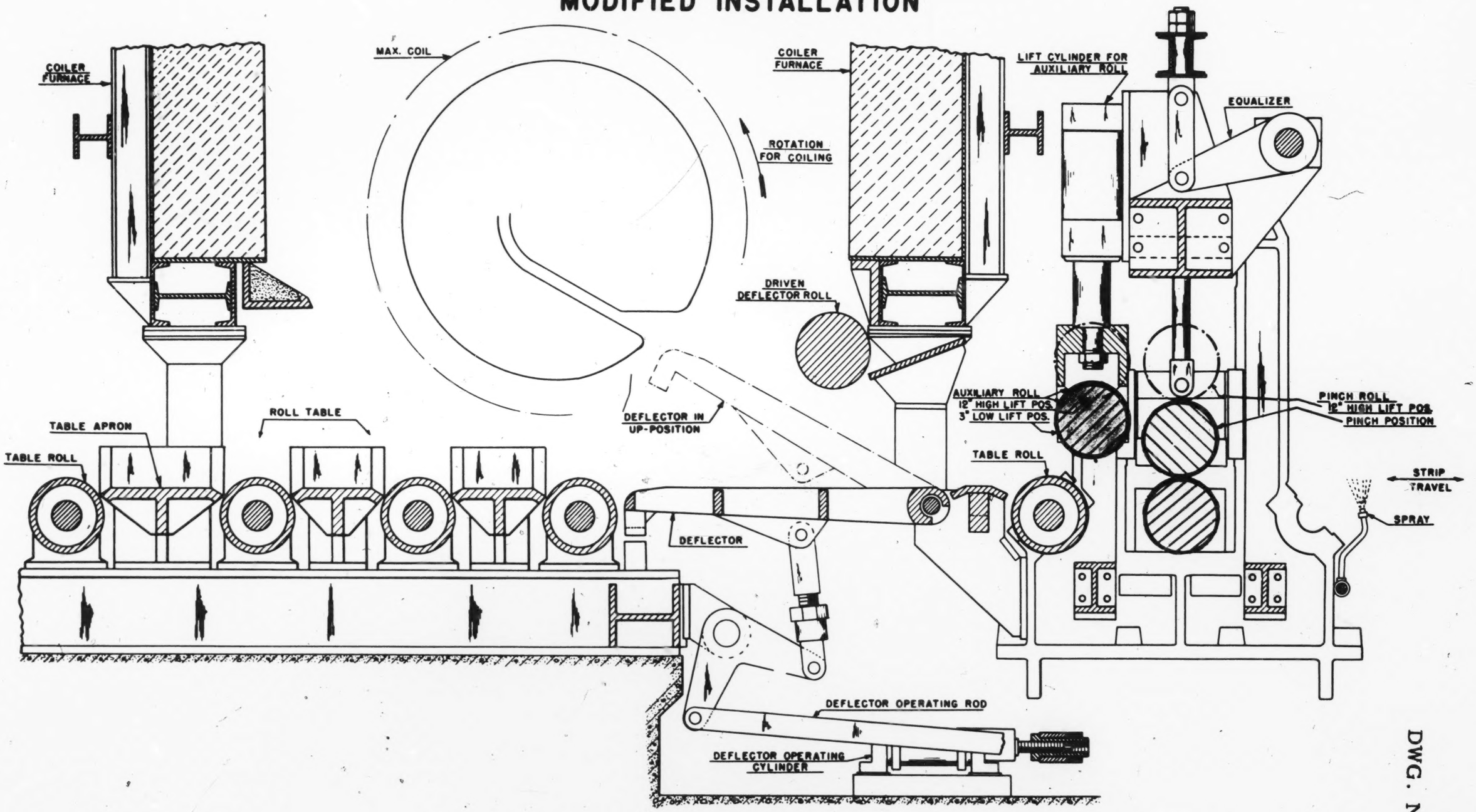
RED SHADED AREA = AREA UNDER AIR PRESSURE

BLUE SHADED AREA = AREA AIRLOCKED (CUSHIONED)

143a

DWG. No. 7

CRUCIBLE HOT STRIP MILL
MODIFIED INSTALLATION

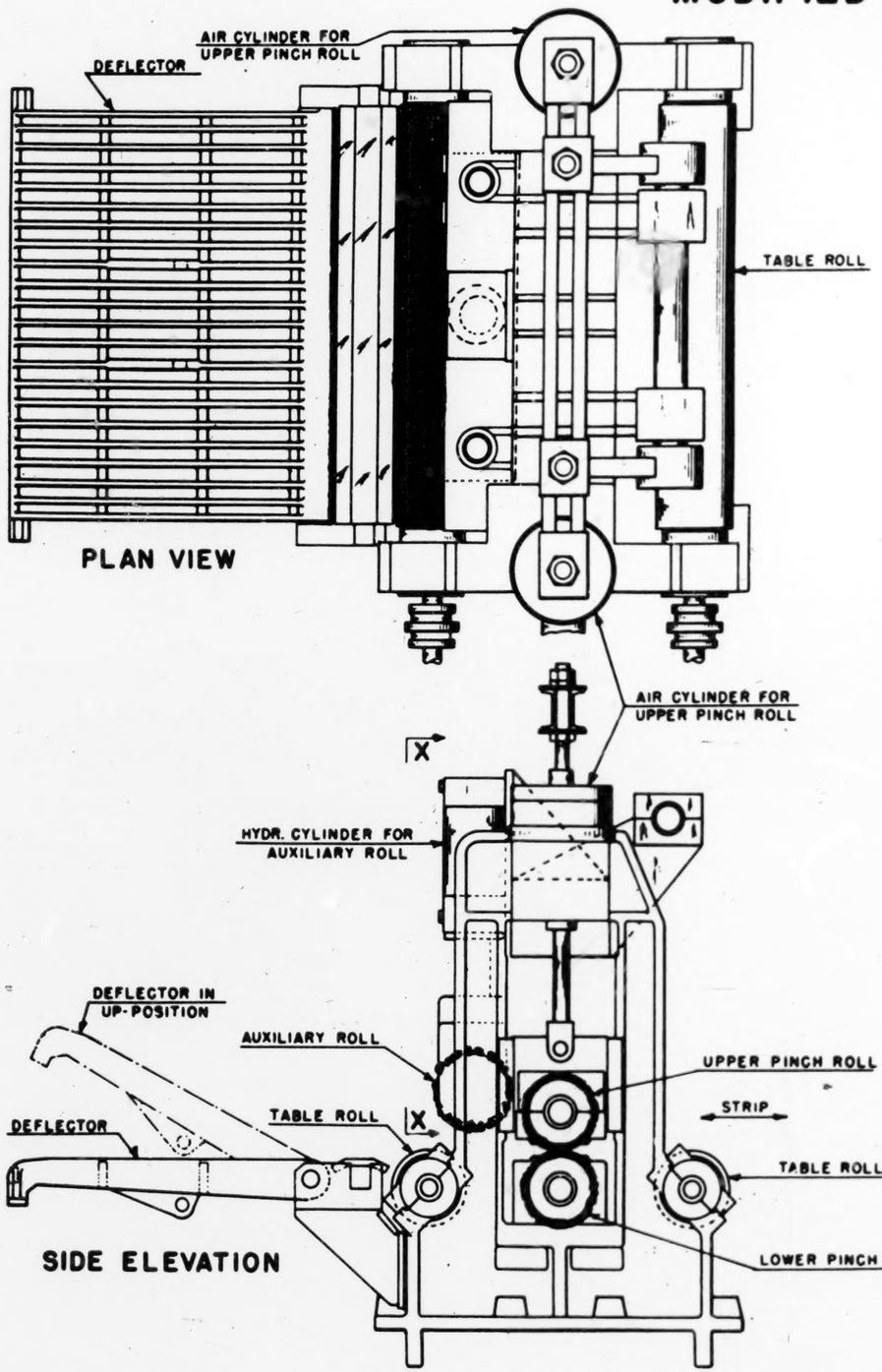


VERTICAL SECTION AT PINCH ROLL & COILER

CRUCIBLE HOT STRIP MILL

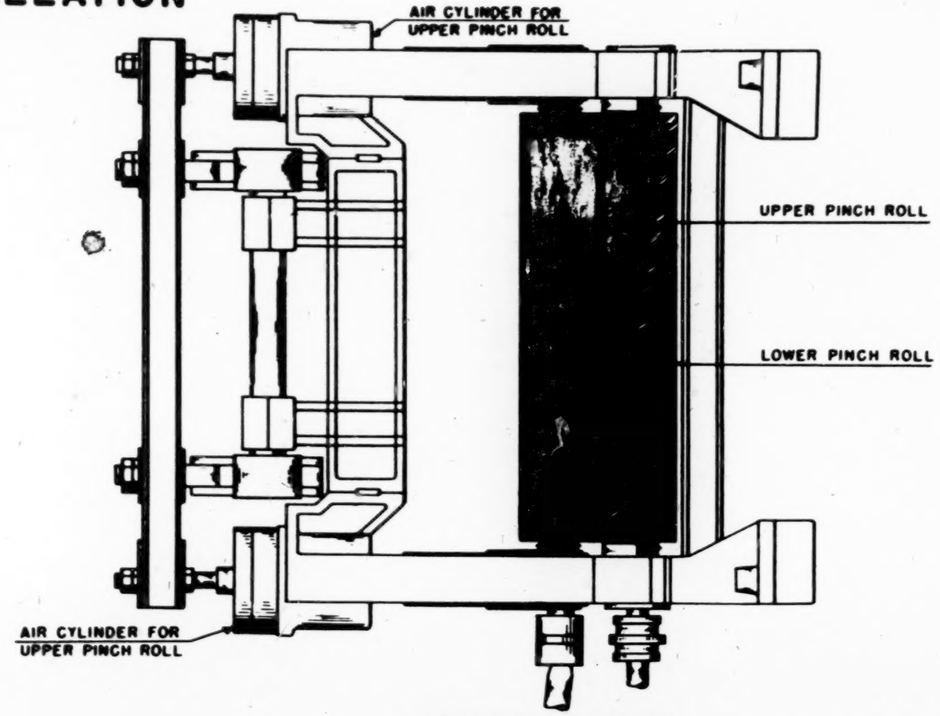
MODIFIED INSTALLATION

DWG. No. 9

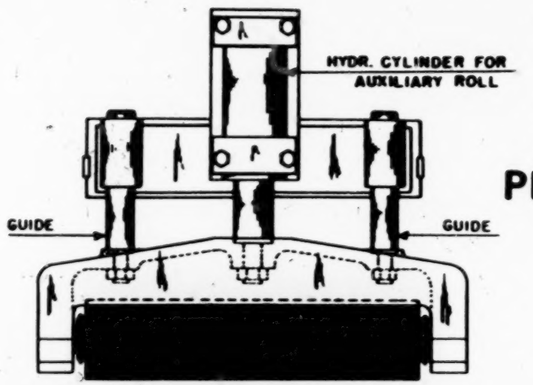


PLAN VIEW

SIDE ELEVATION



FRONT ELEVATION



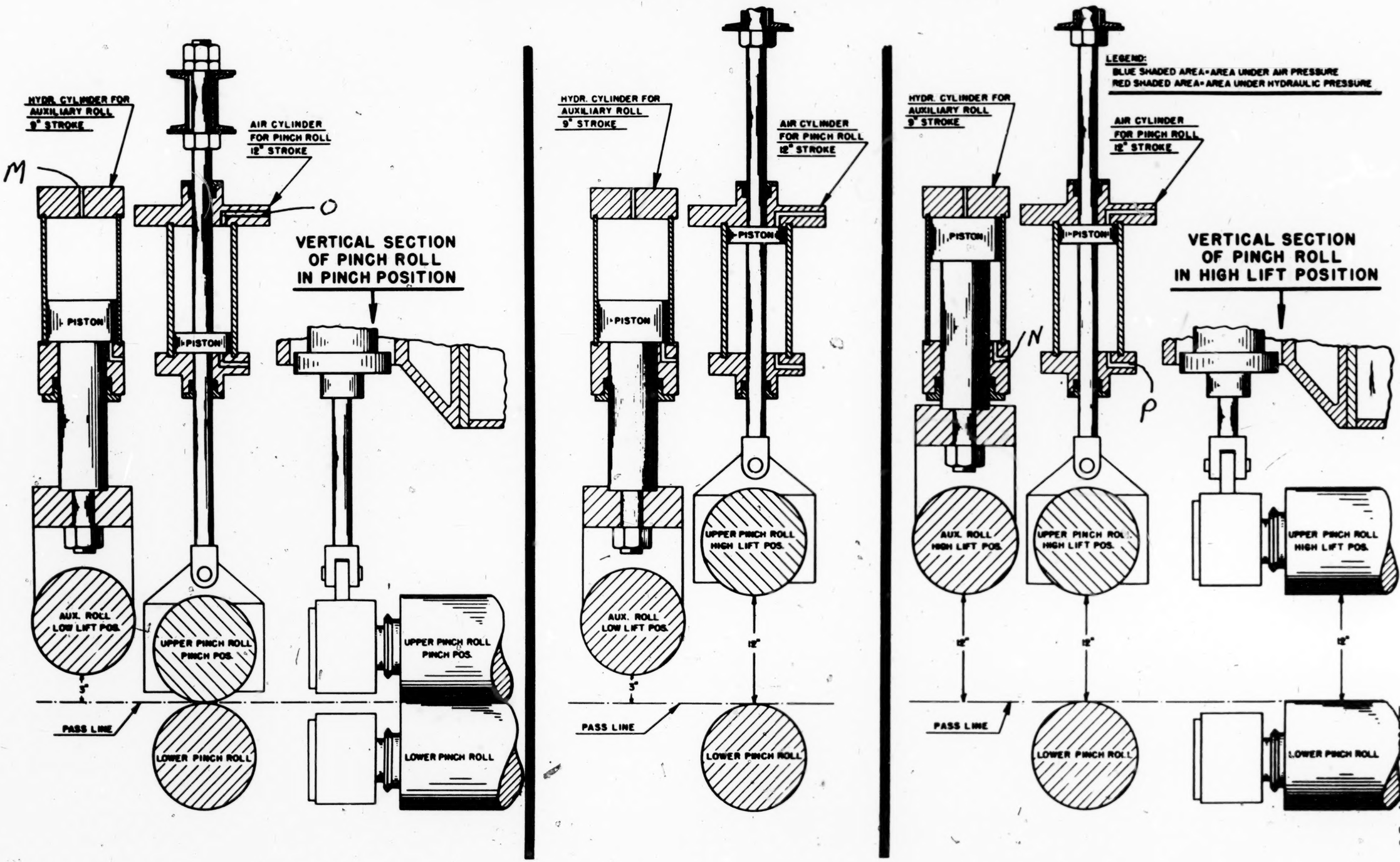
VIEW X-X
AUX. ROLL ARR'G'T.

DEFLECTOR AND PINCH ROLL ASSEMBLY

CRUCIBLE HOT STRIP MILL

PINCH ROLL & AUXILIARY ROLL OPERATION

DWG. No. 10



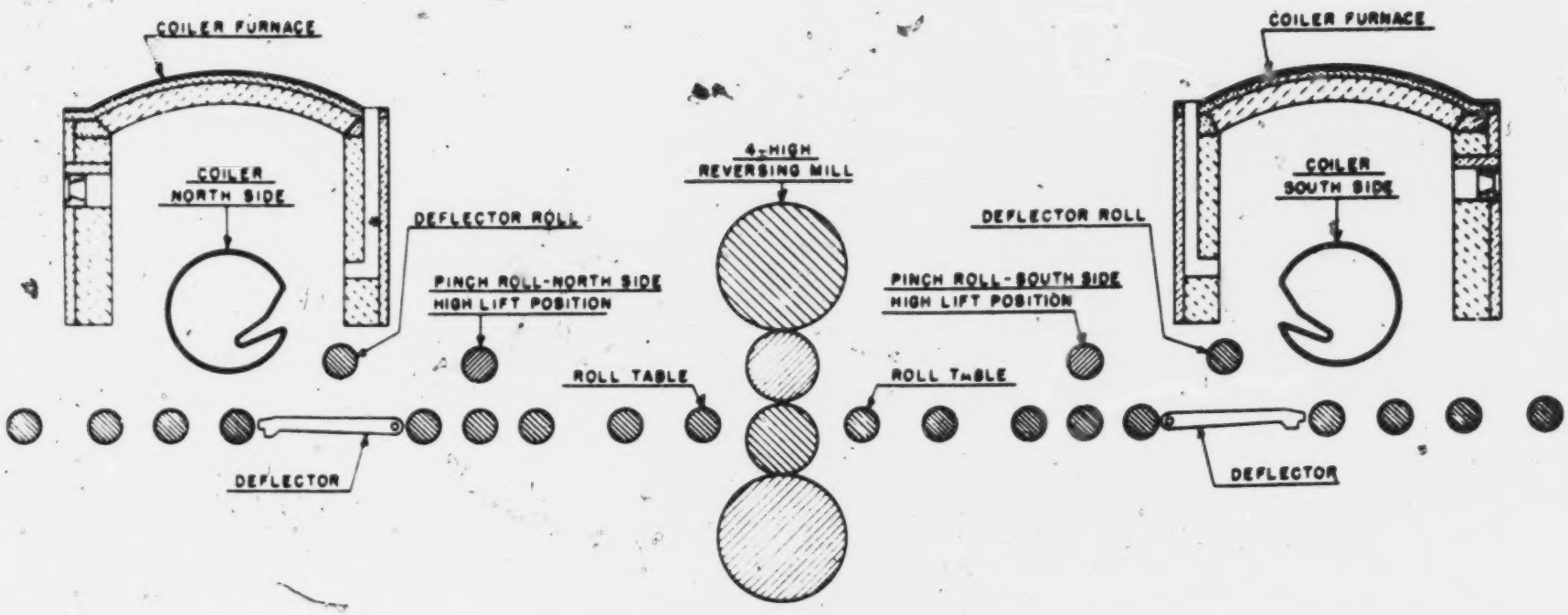
DRG. No. 10

149a

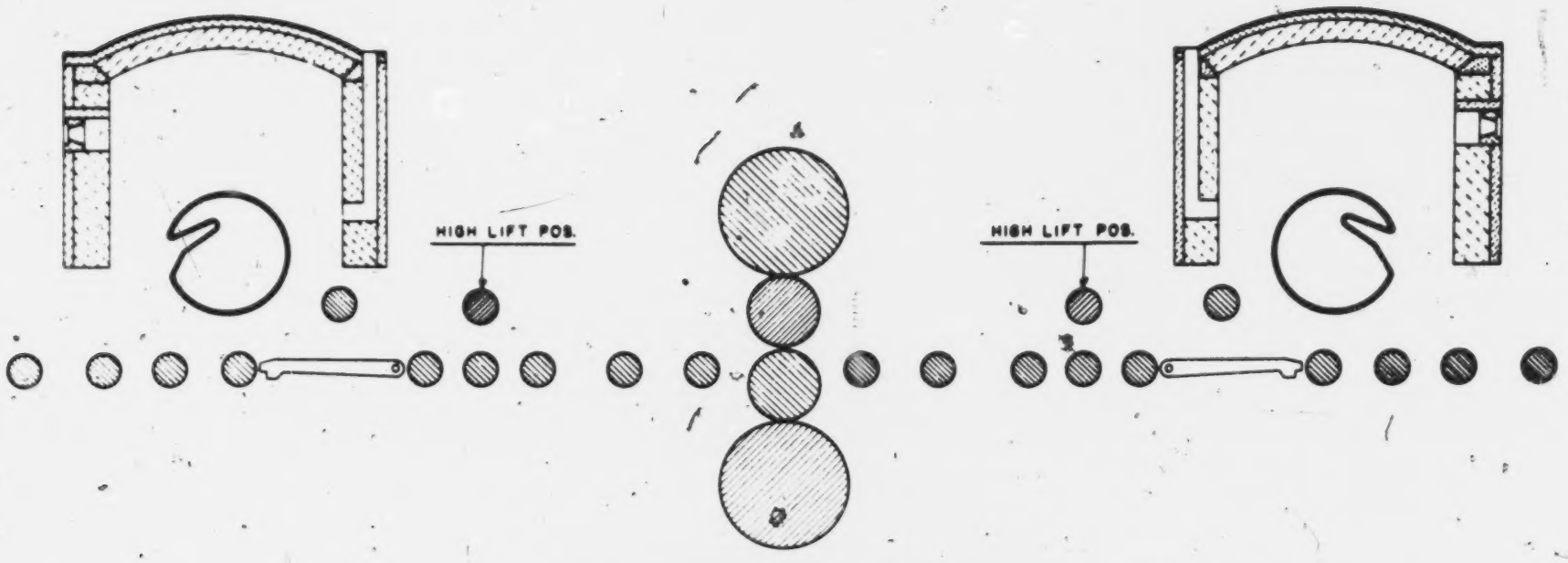
DWG. No. 11

CRUCIBLE HOT STRIP MILL

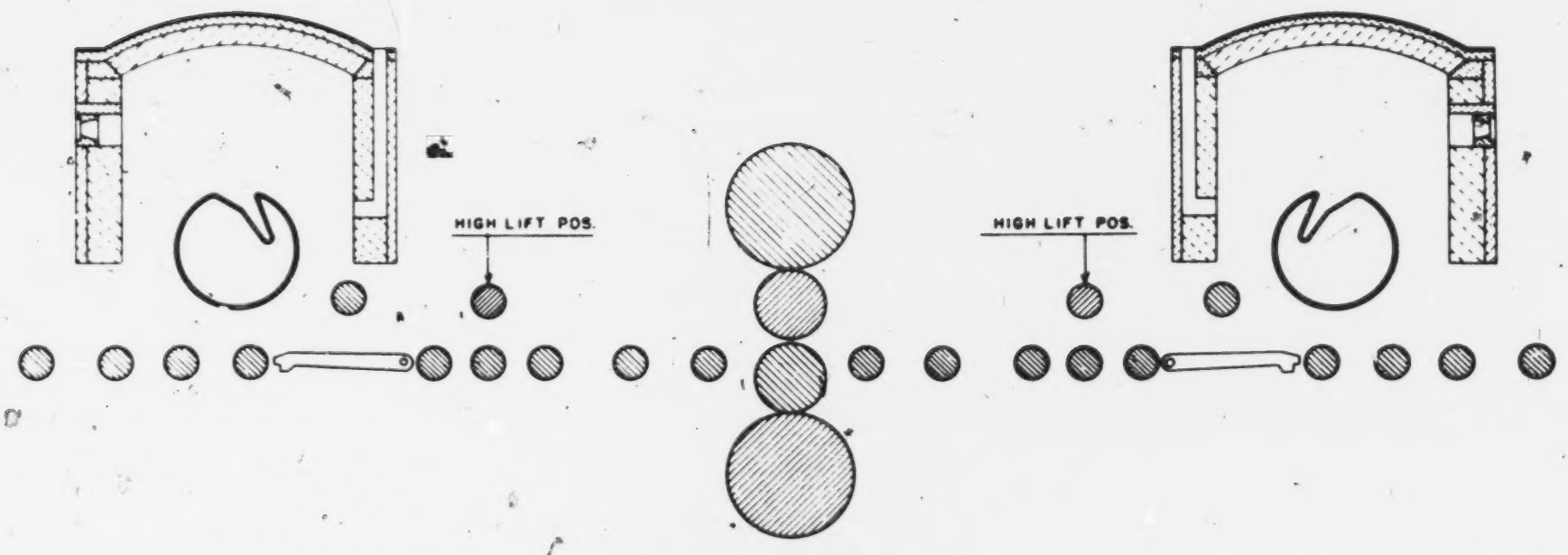
OPERATION OF ORIGINAL MILL



FIRST PASS STARTED



FIRST PASS DURING ROLLING

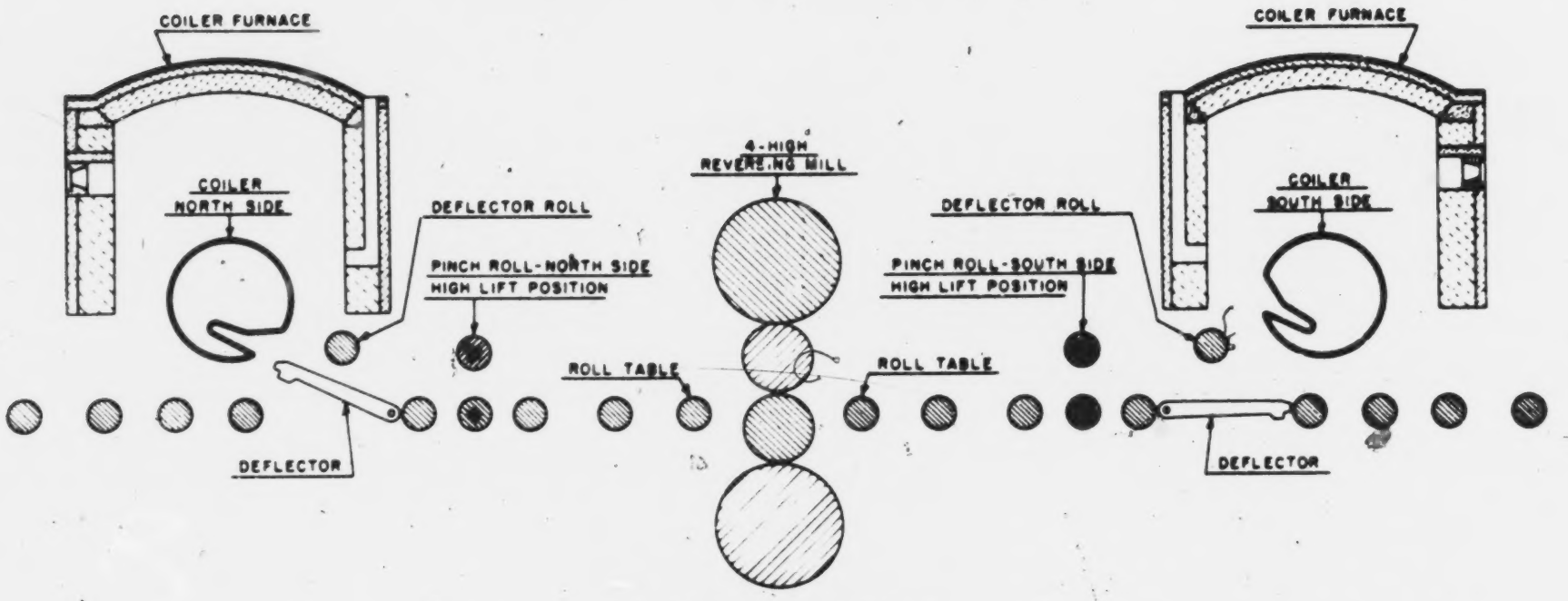


FIRST PASS COMPLETED

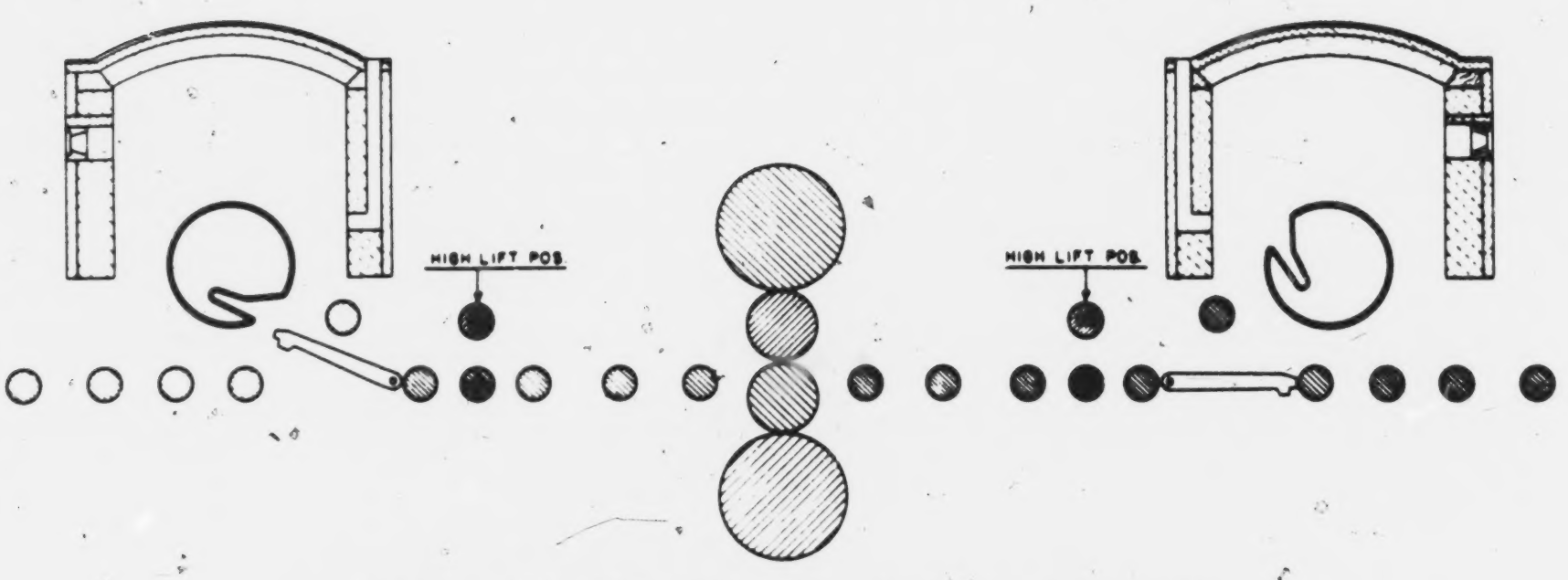
DWG. No. 12

CRUCIBLE HOT STRIP MILL

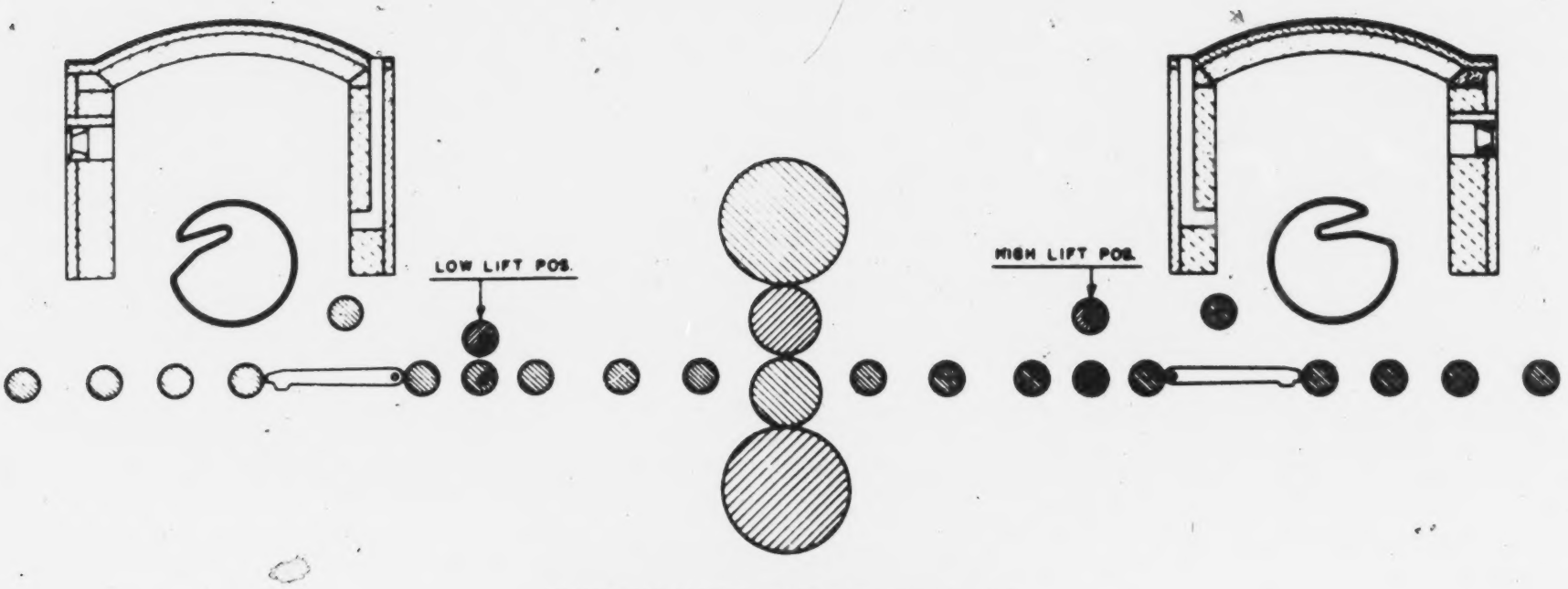
OPERATION OF ORIGINAL MILL



SECOND PASS STARTED



SECOND PASS - STRIP ENTERING COILER ON NORTH SIDE

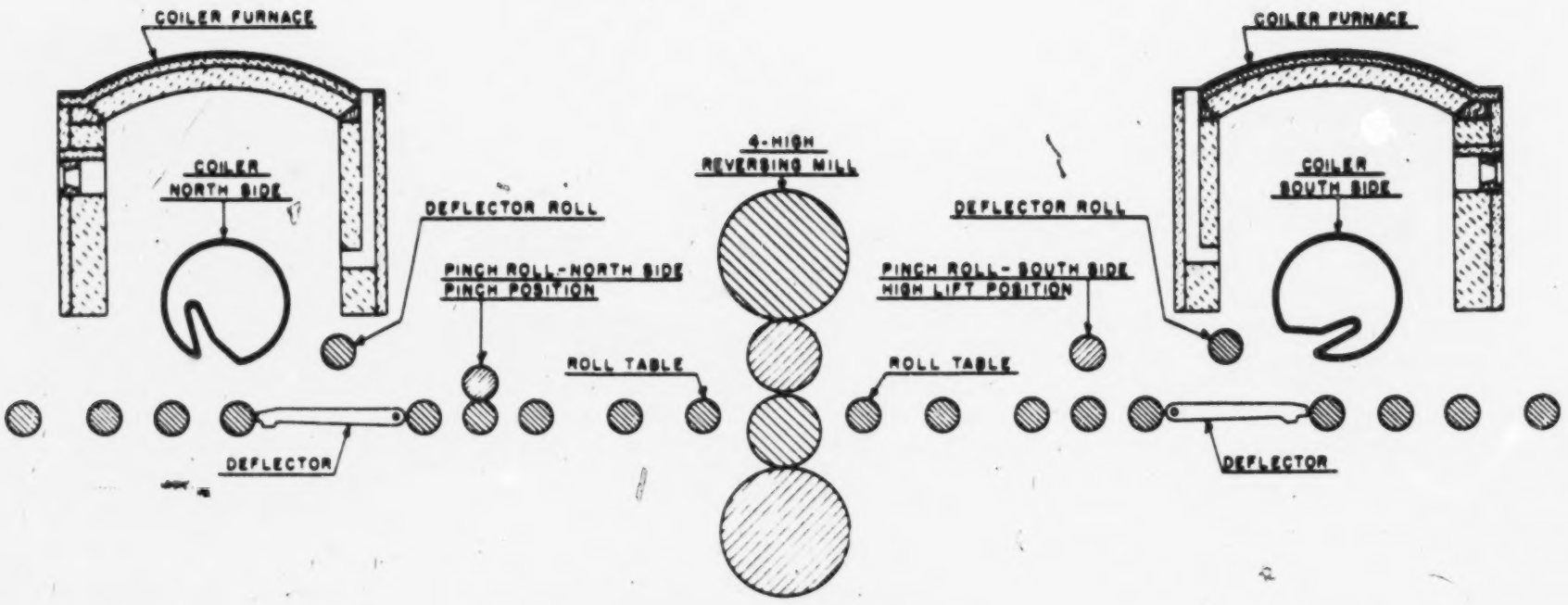


SECOND PASS DURING ROLLING

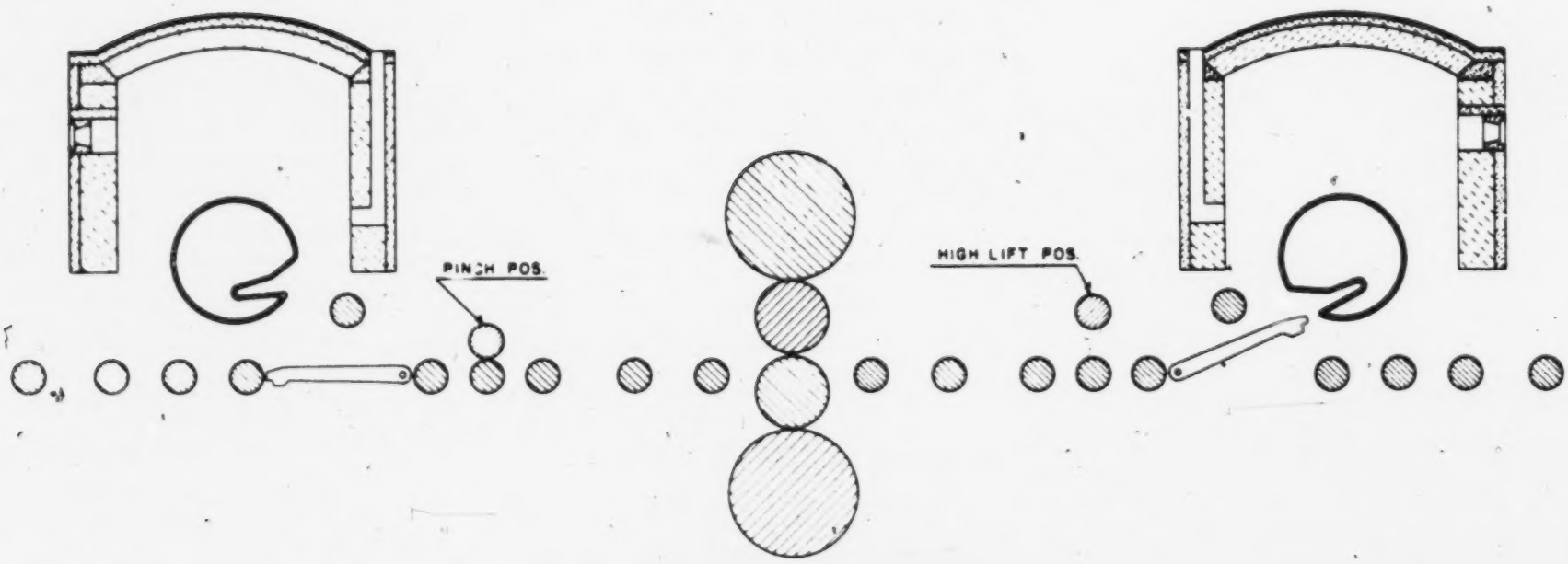
DWG. No. 13

CRUCIBLE HOT STRIP MILL

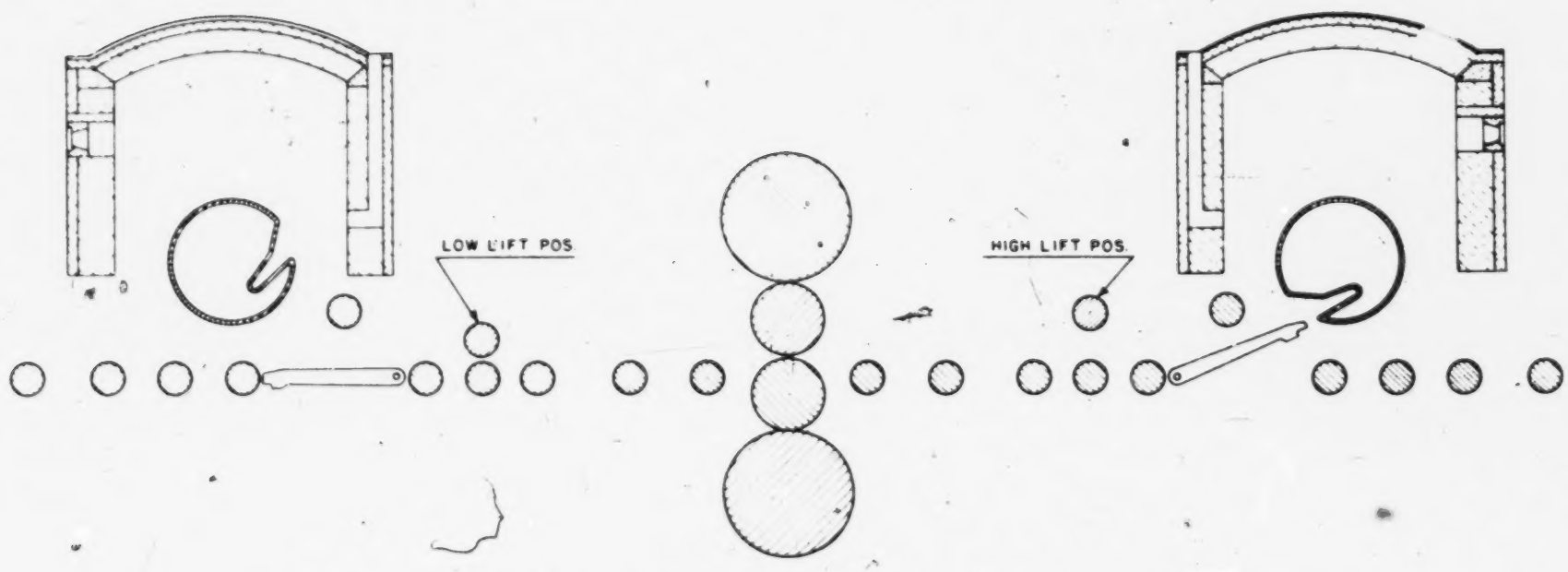
OPERATION OF ORIGINAL MILL



SECOND PASS COMPLETED



THIRD PASS STARTED

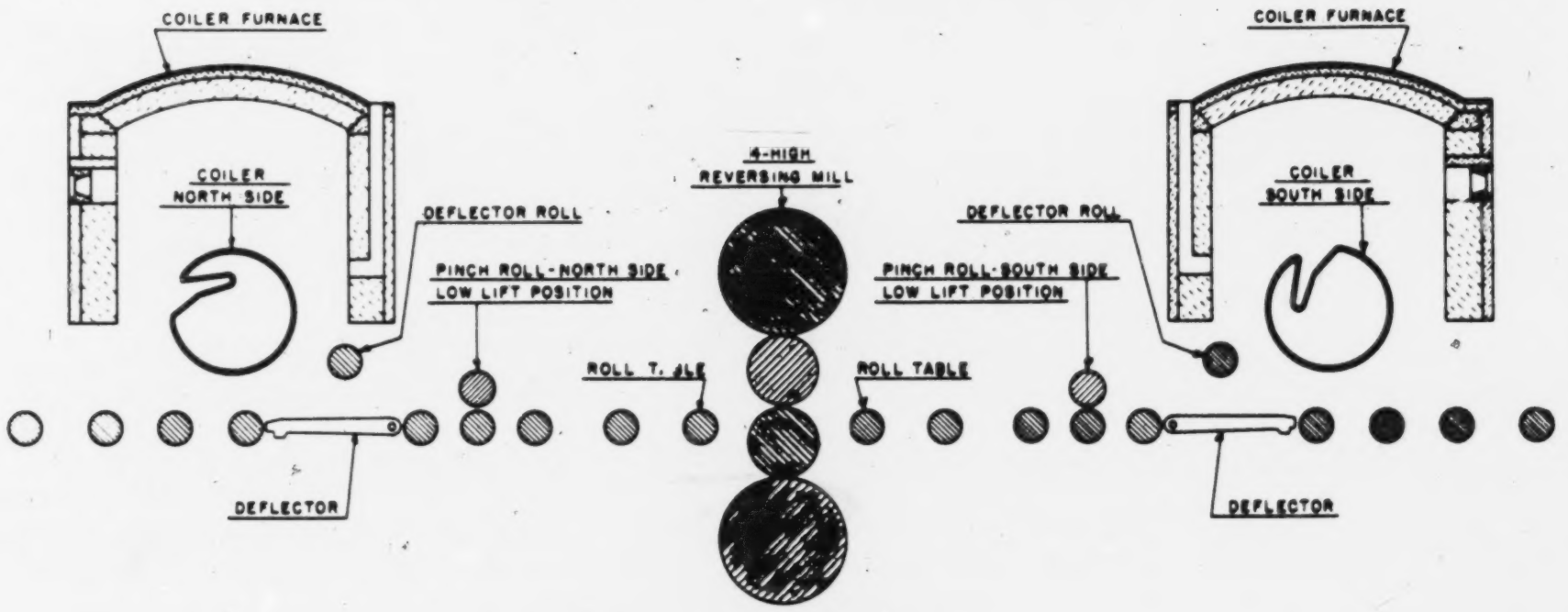


THIRD PASS - STRIP ENTERING COILER ON SOUTH SIDE

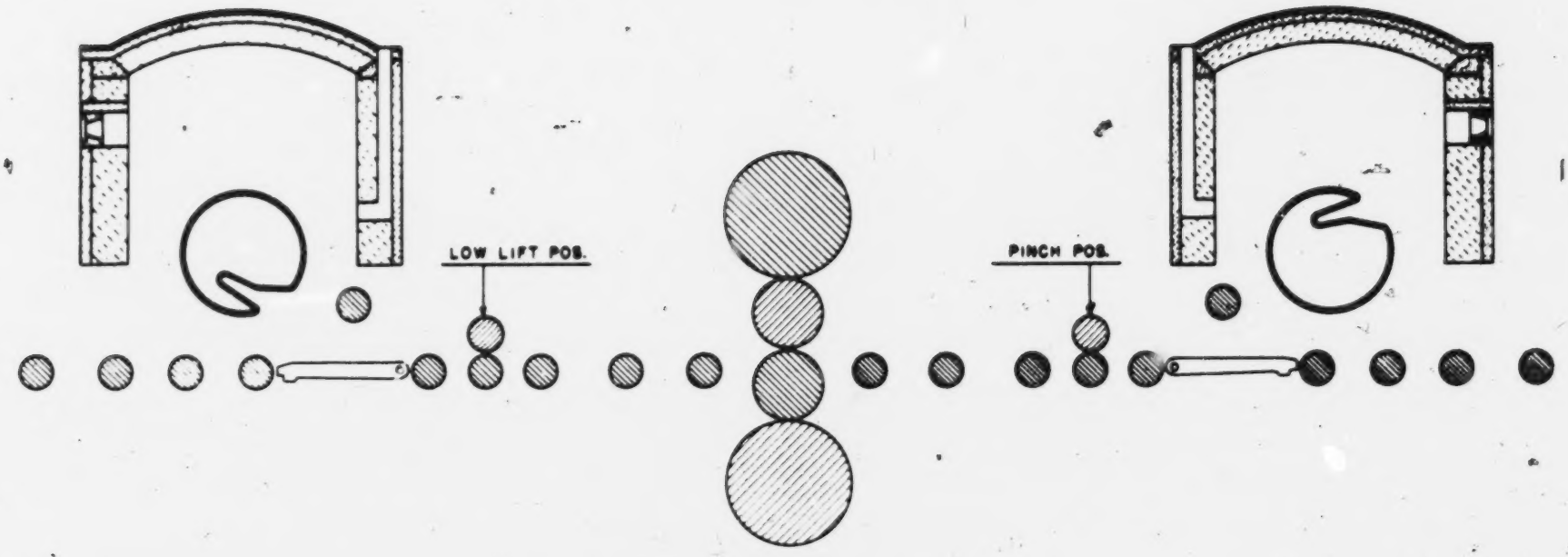
DWG. No. 14

CRUCIBLE HOT STRIP MILL

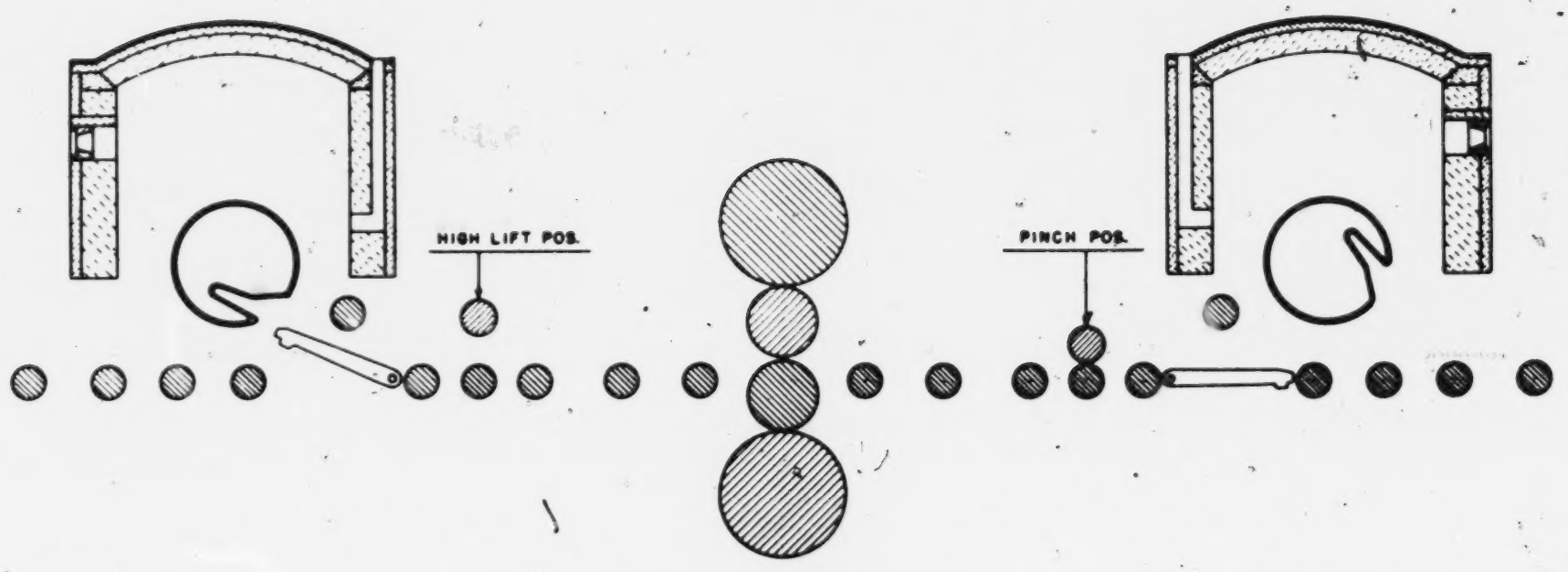
OPERATION OF ORIGINAL MILL



THIRD PASS DURING ROLLING



THIRD PASS COMPLETED

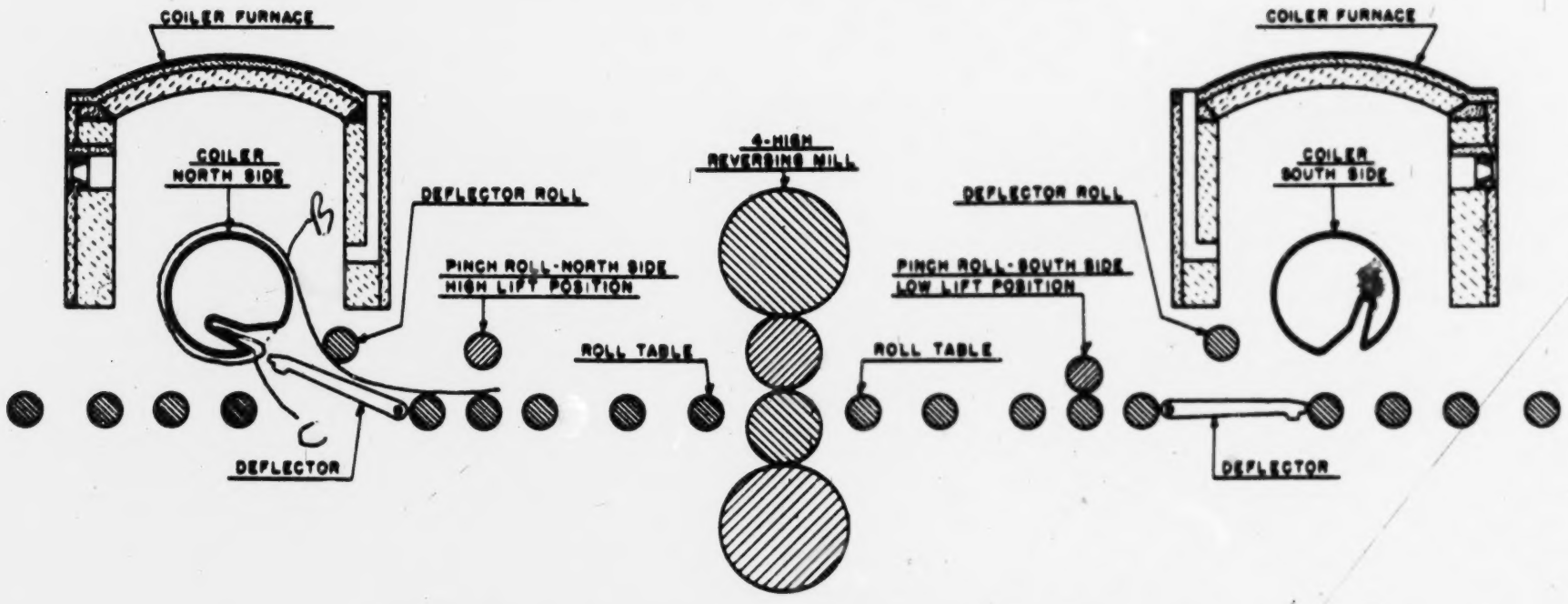


FOURTH PASS STARTED

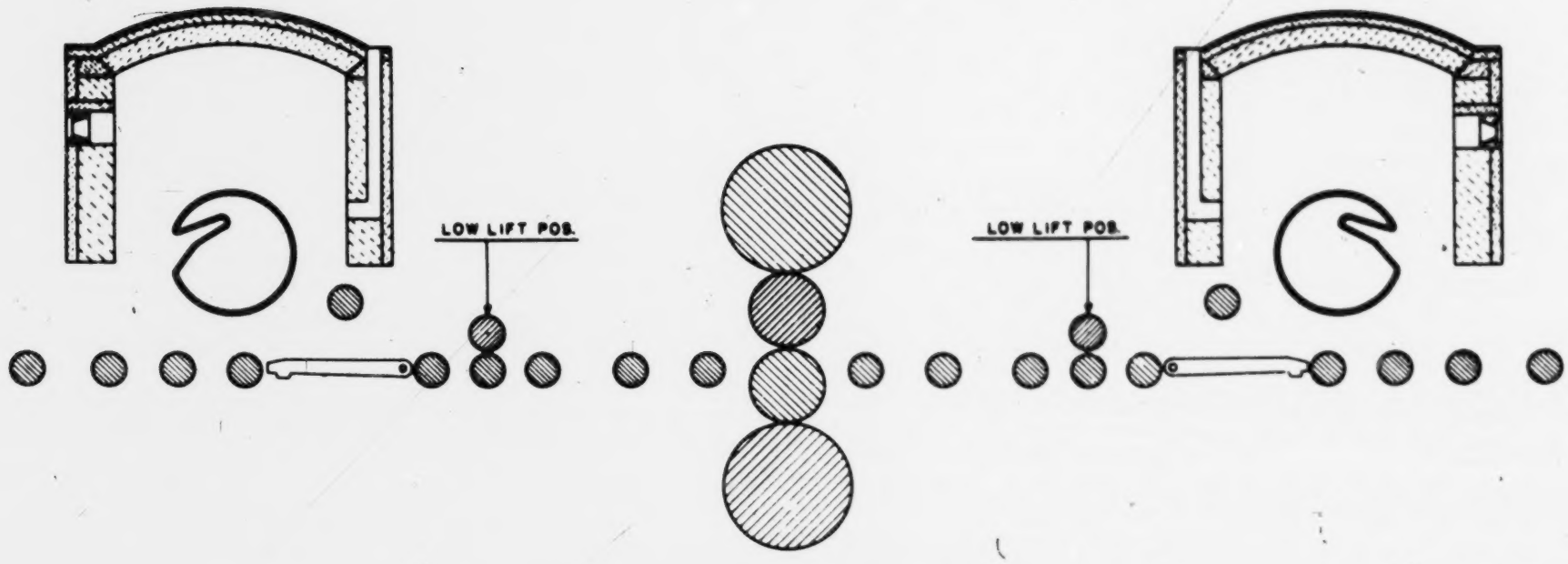
DWG. No. 15

CRUCIBLE HOT STRIP MILL

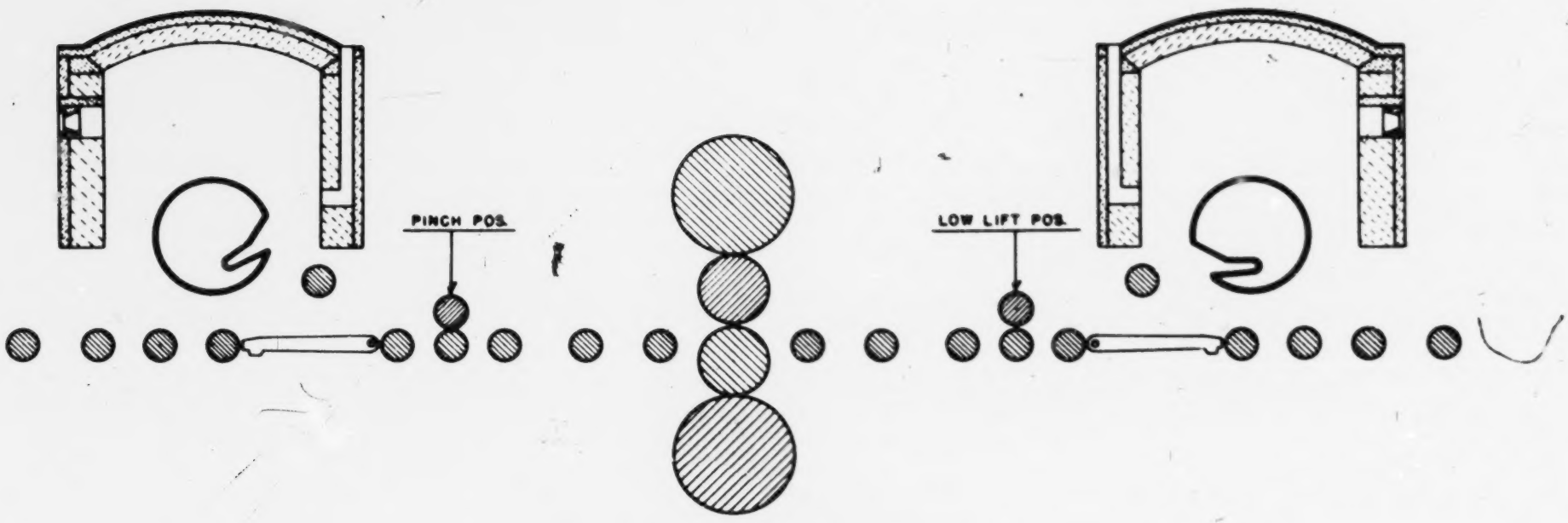
OPERATION OF ORIGINAL MILL



FOURTH PASS - STRIP ENTERING COILER ON NORTH SIDE



FOURTH PASS DURING ROLLING

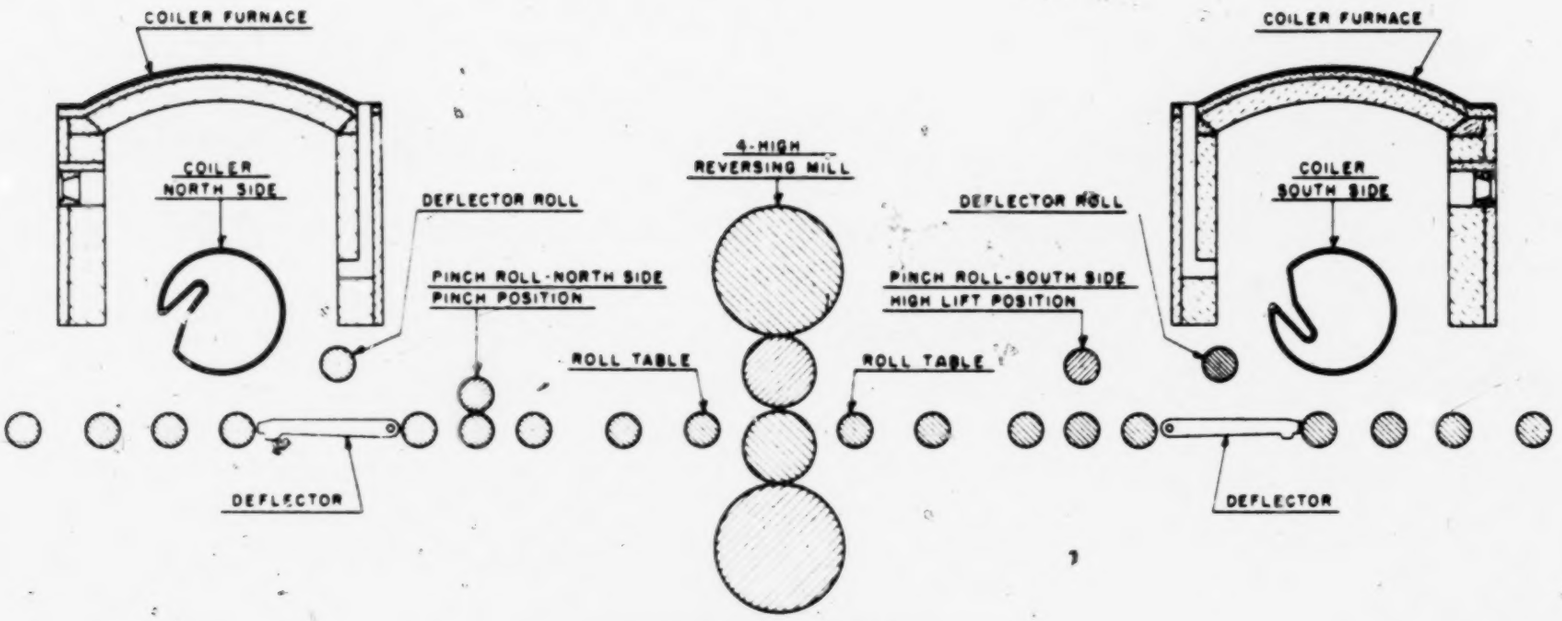


FOURTH PASS COMPLETED

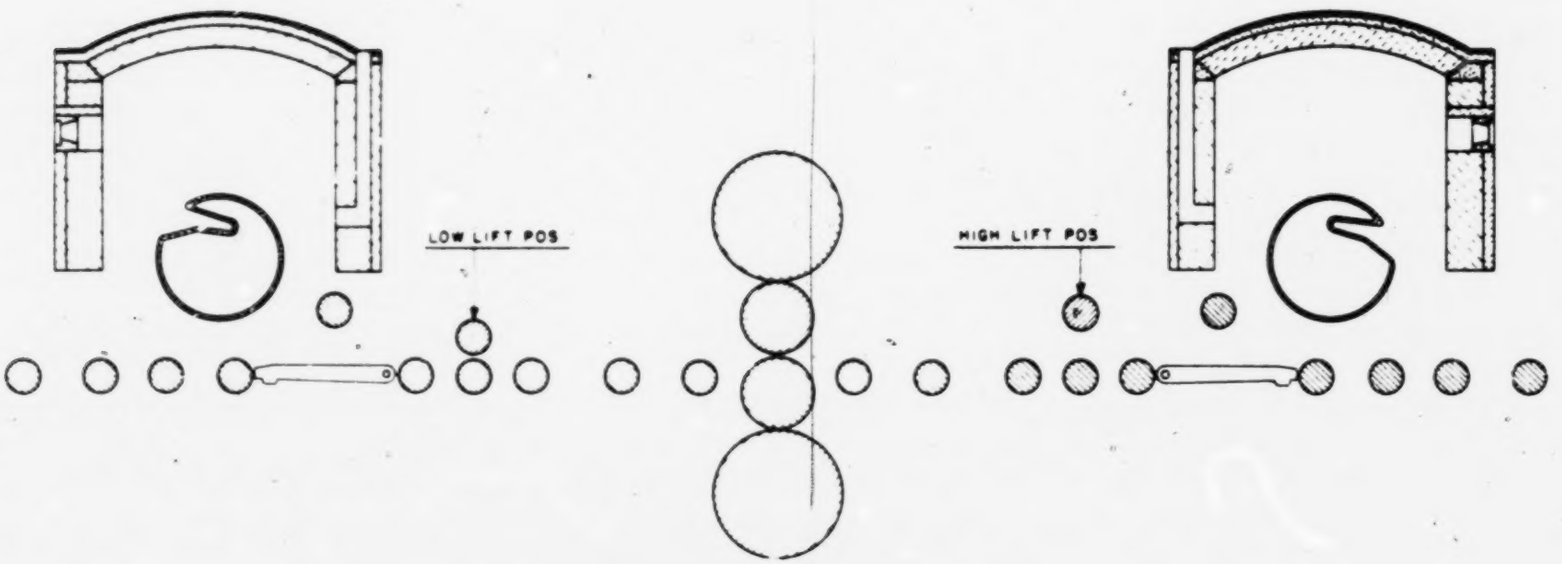
DWG. No. 16

CRUCIBLE HOT STRIP MILL

OPERATION OF ORIGINAL MILL



FINAL PASS STARTED

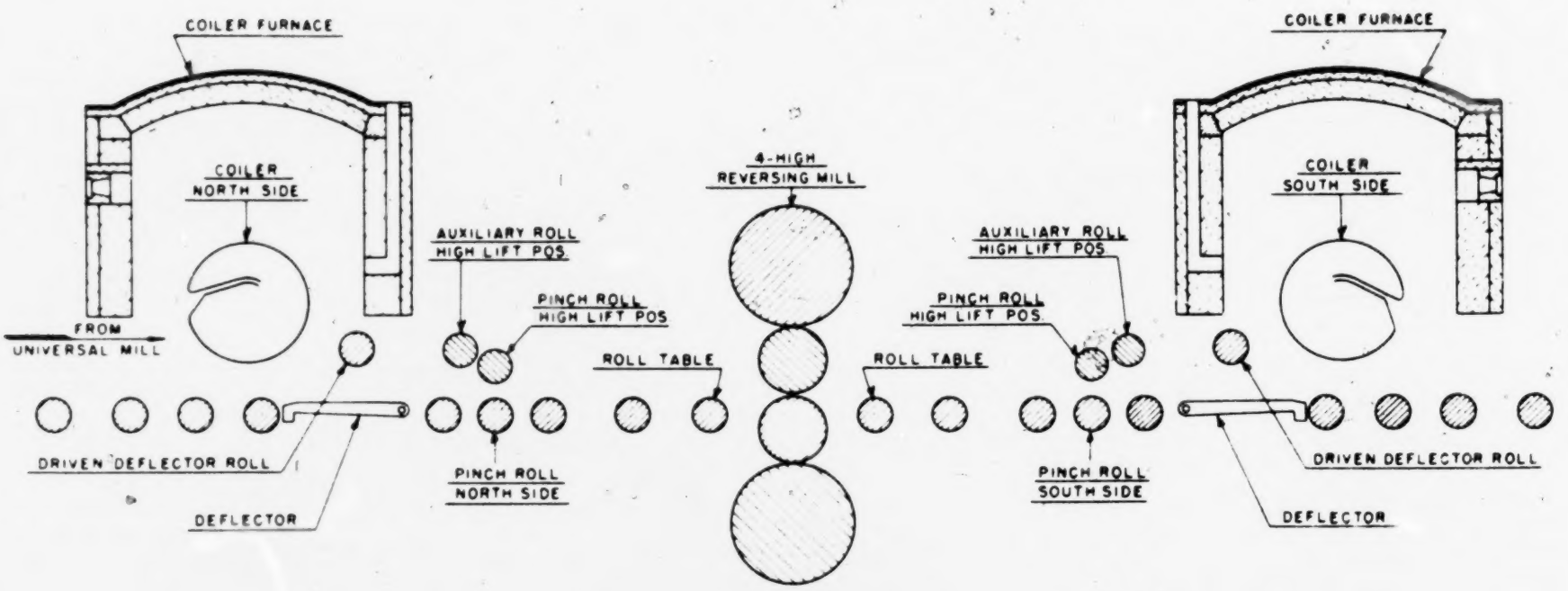


FINAL PASS DURING ROLLING

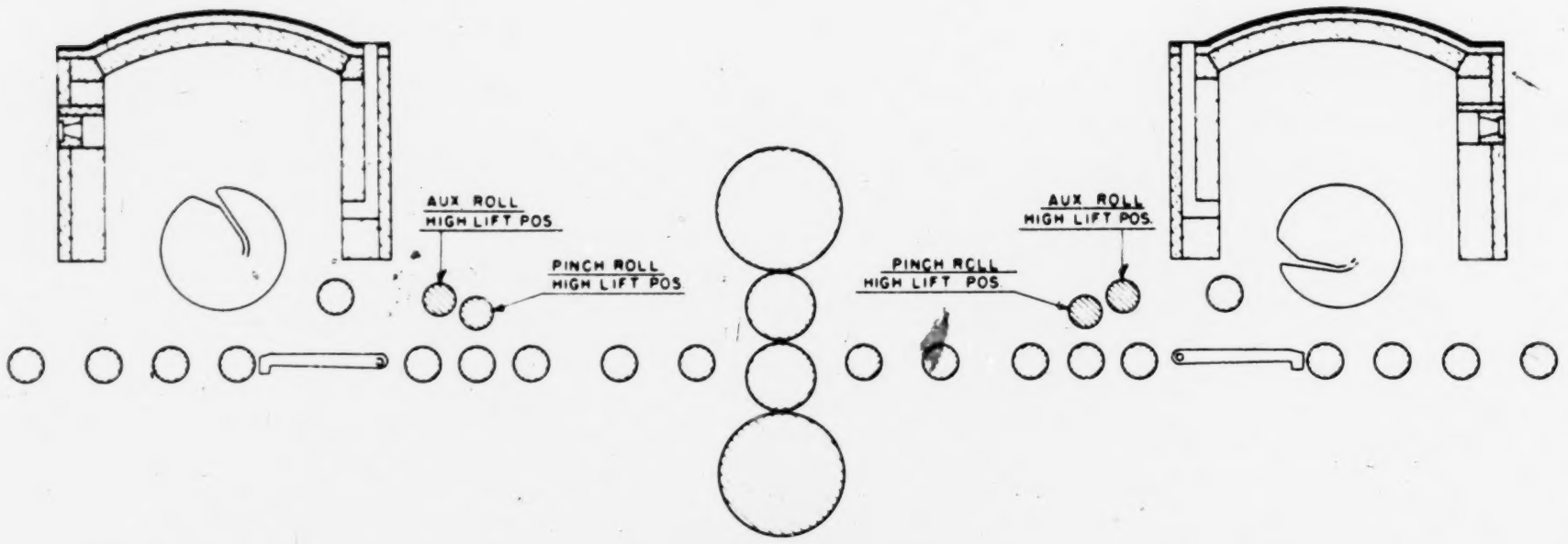
DWG. No. 17

CRUCIBLE HOT STRIP MILL

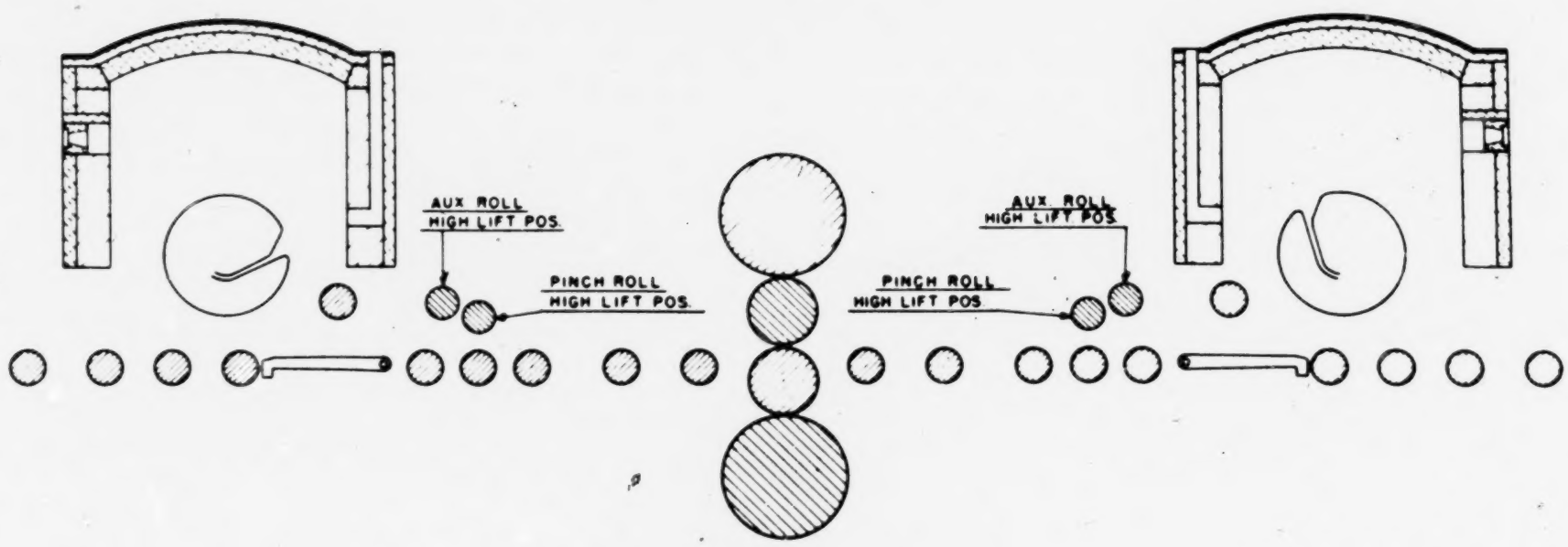
OPERATION OF MODIFIED MILL



FIRST PASS STARTED



FIRST PASS ROLLING

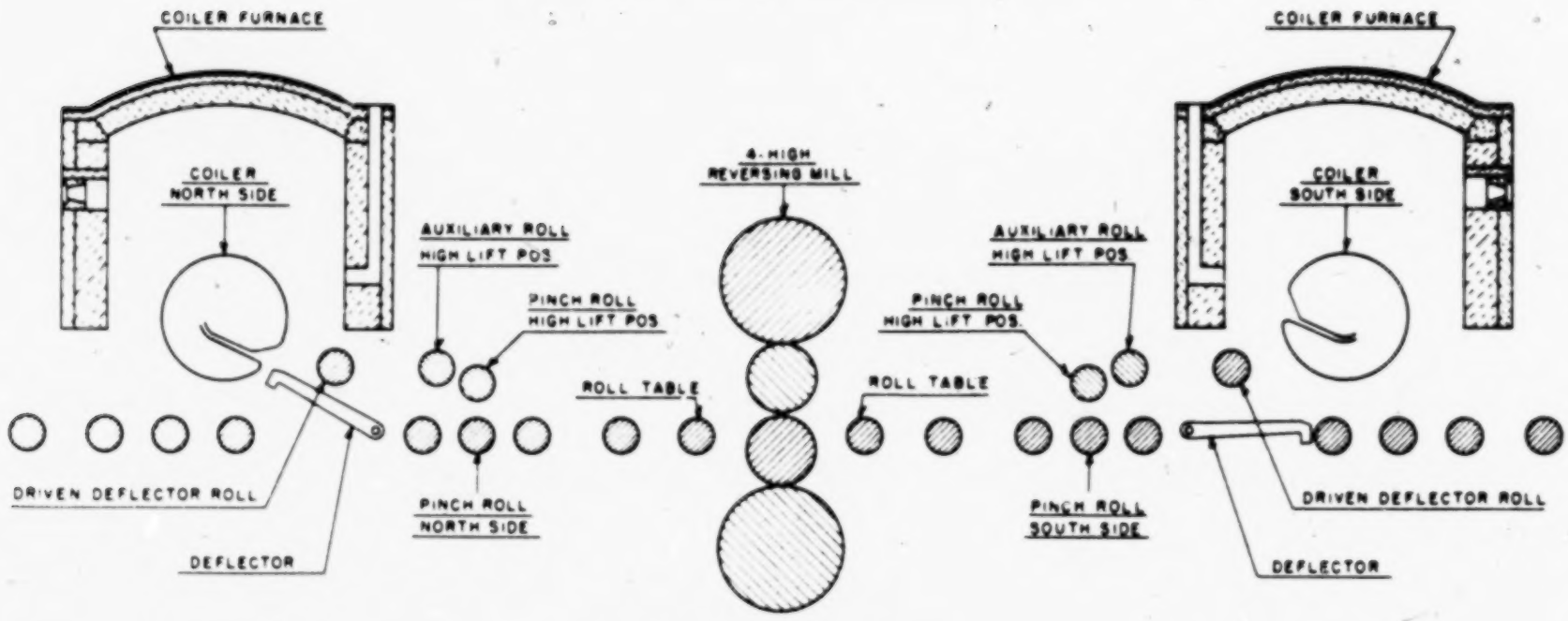


FIRST PASS COMPLETED

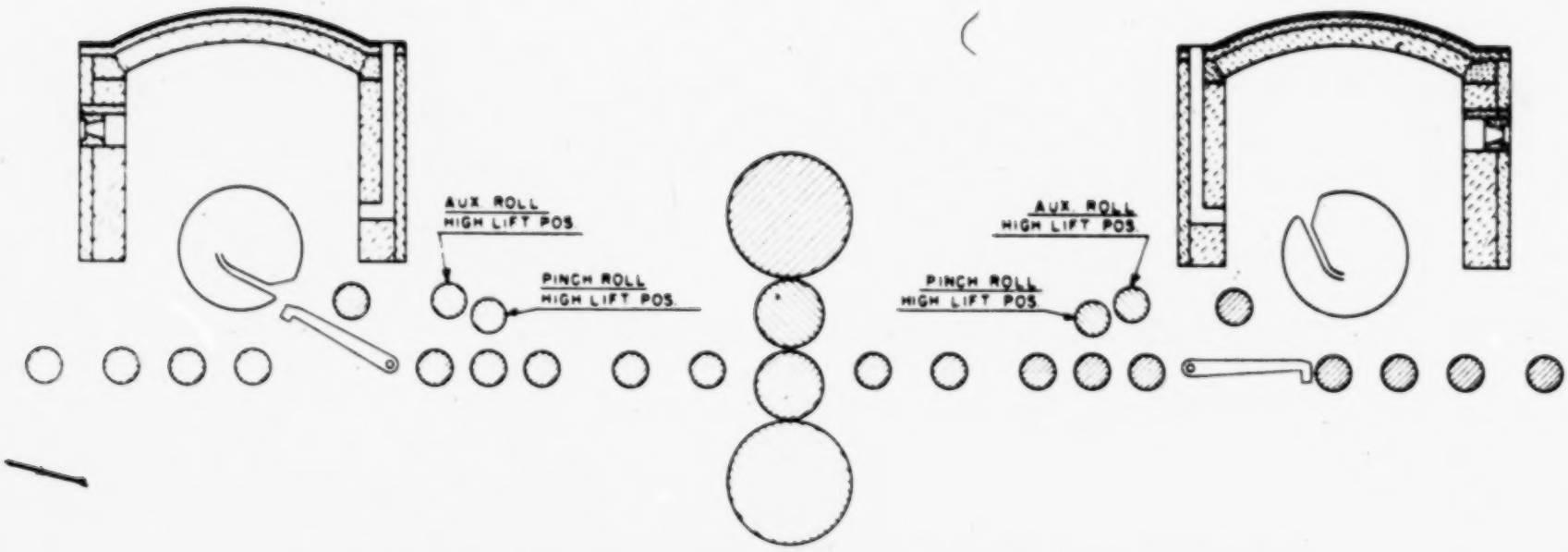
DWG. No. 18

CRUCIBLE HOT STRIP MILL

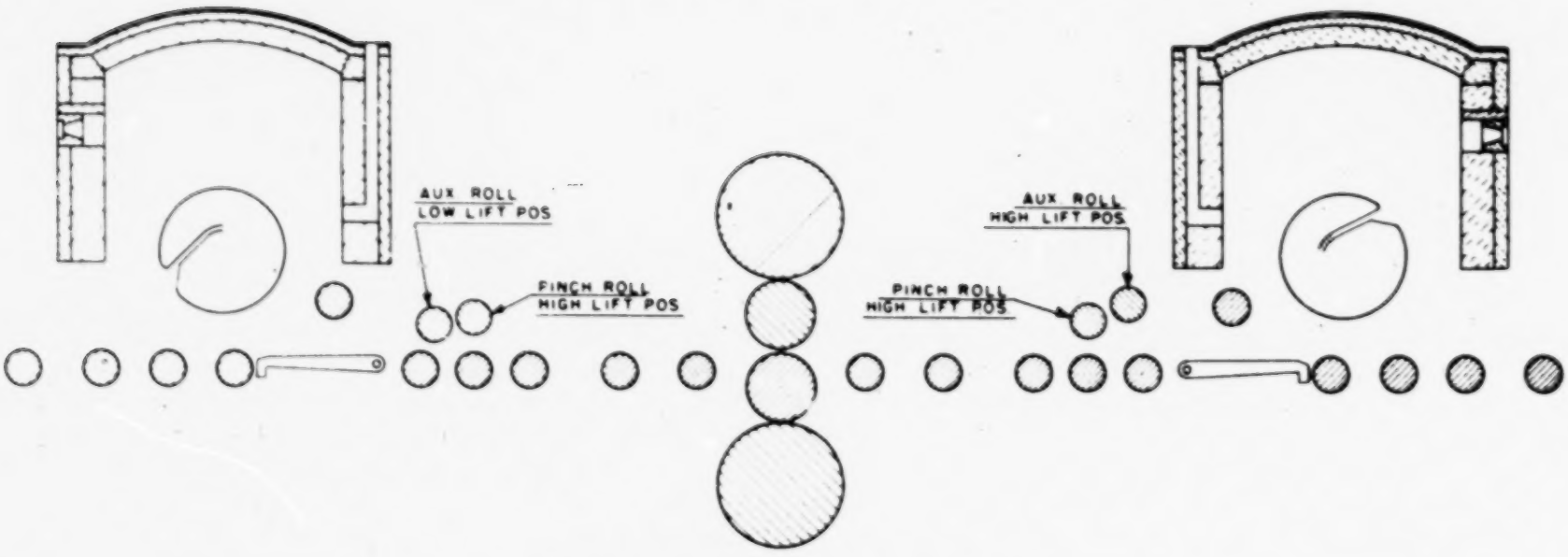
OPERATION OF MODIFIED MILL



SECOND PASS STARTED



SECOND PASS-STRIP ENTERING COILER ON NORTH SIDE

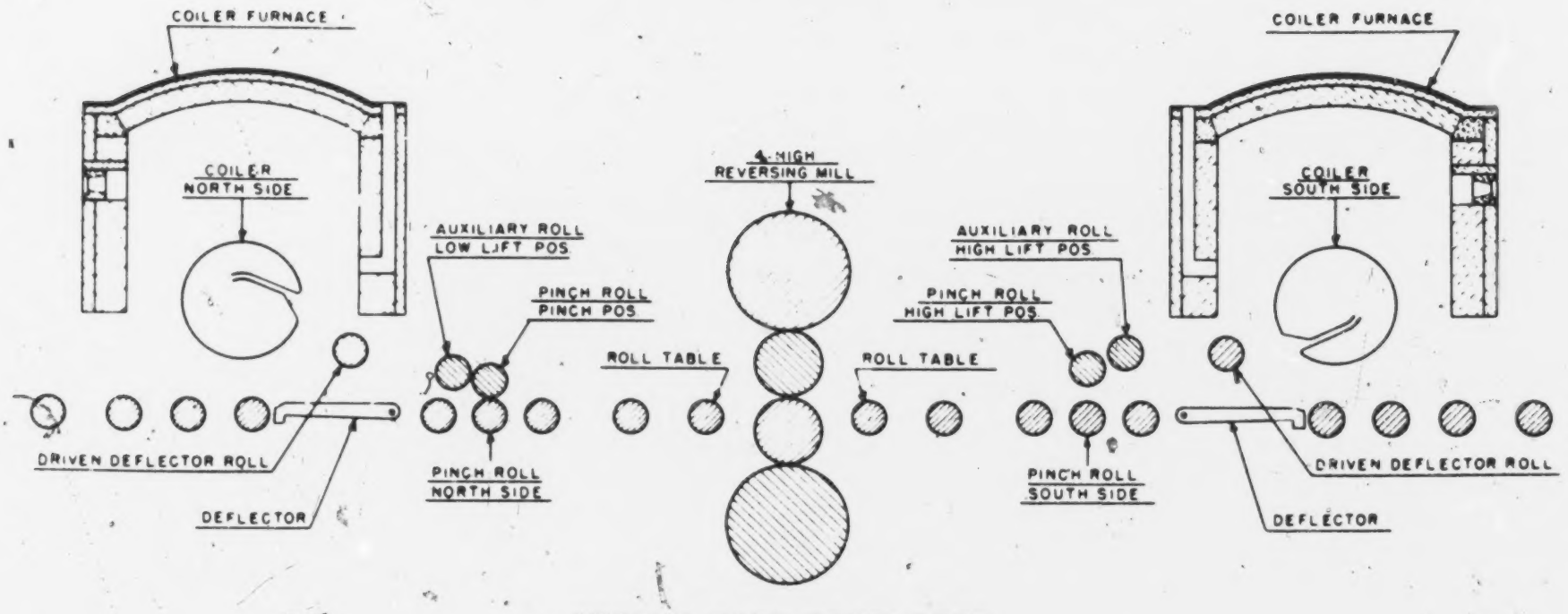


SECOND PASS DURING ROLLING

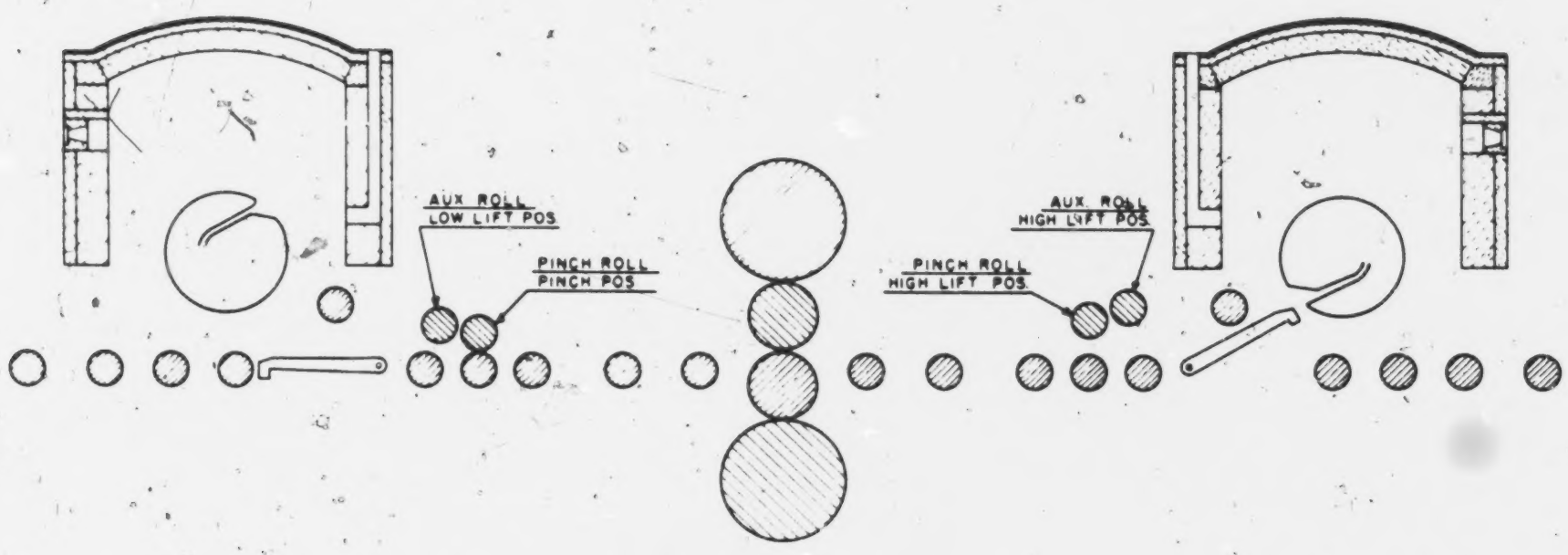
DWG. No. 19

CRUCIBLE HOT STRIP MILL

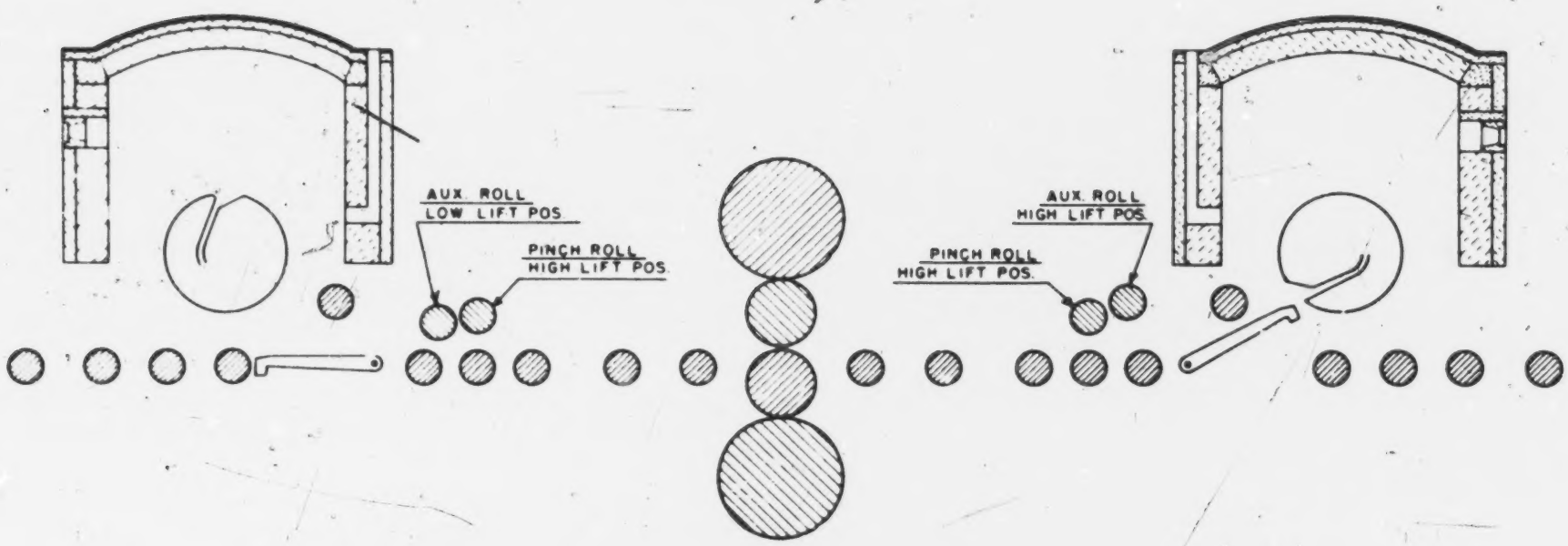
OPERATION OF MODIFIED MILL



SECOND PASS COMPLETED



THIRD PASS STARTED

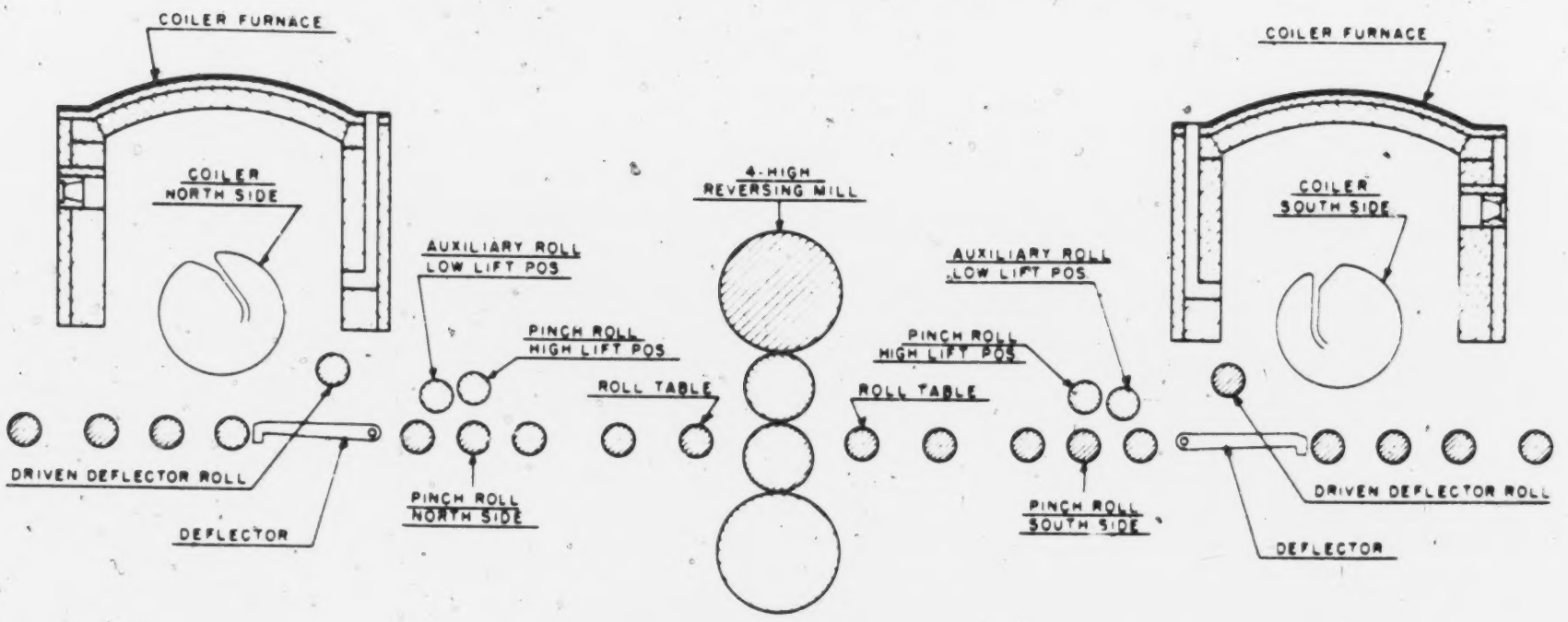


THIRD PASS - STRIP ENTERING COILER ON SOUTH SIDE

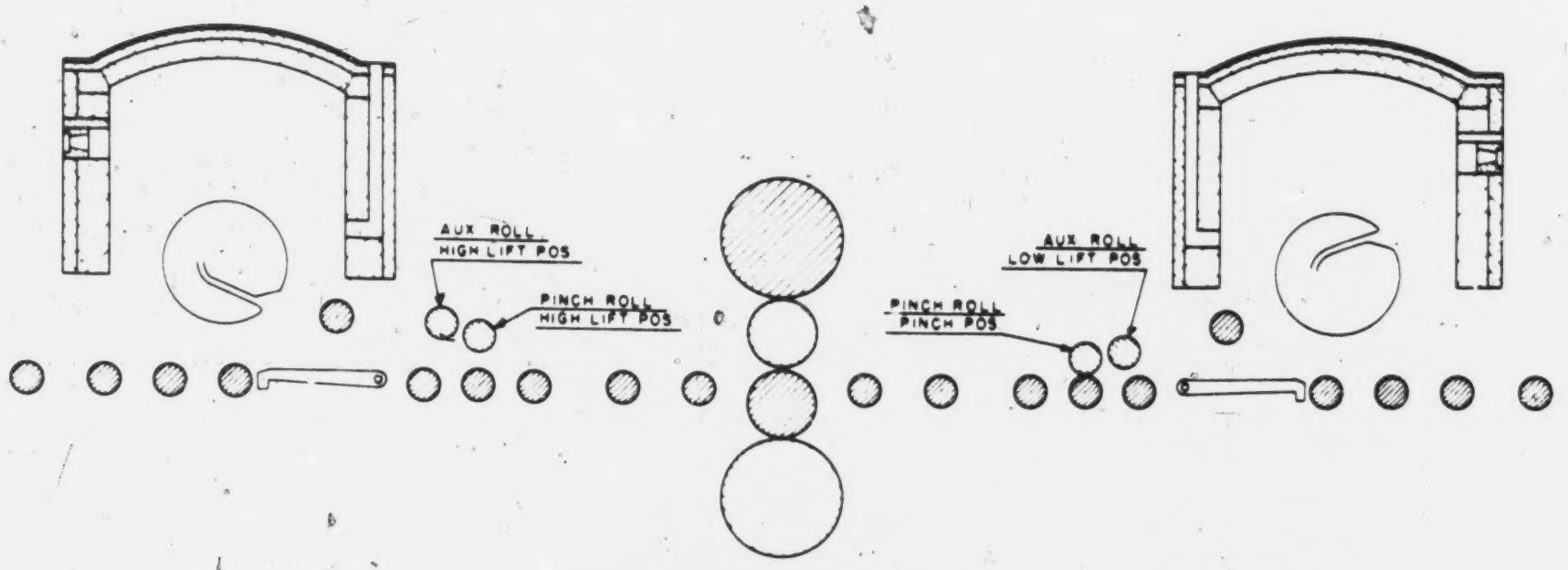
DWG. No. 20

CRUCIBLE HOT STRIP MILL

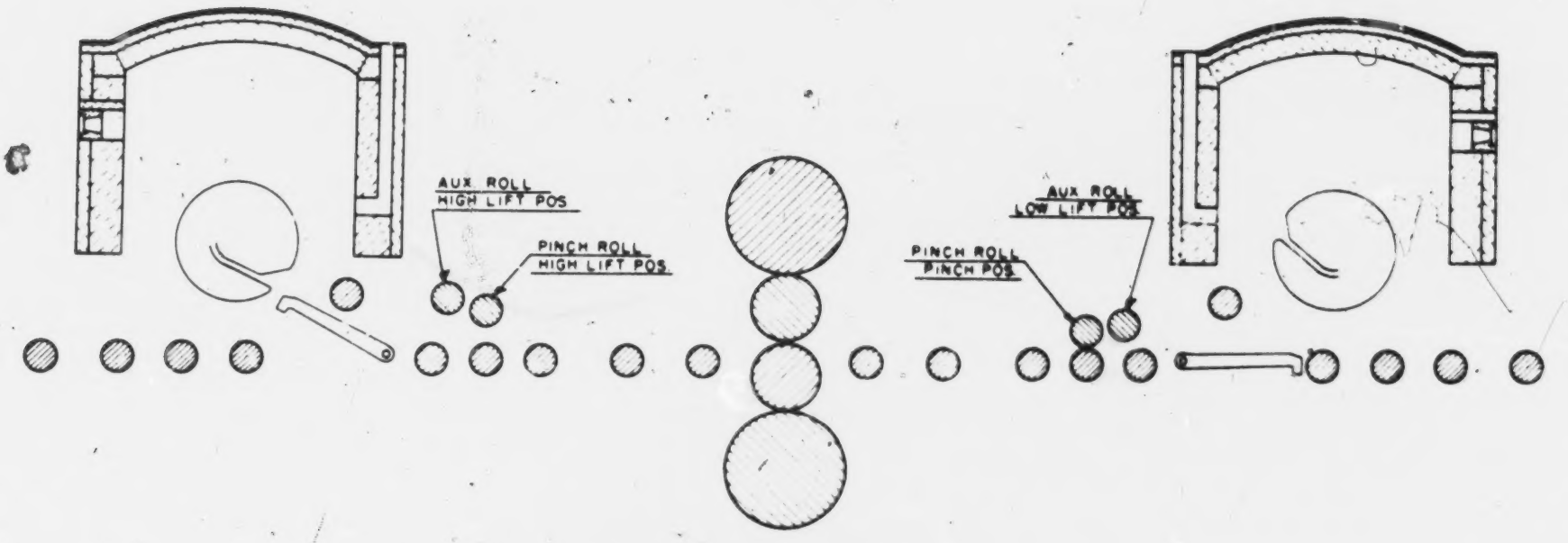
OPERATION OF MODIFIED MILL



THIRD PASS DURING ROLLING



THIRD PASS COMPLETED

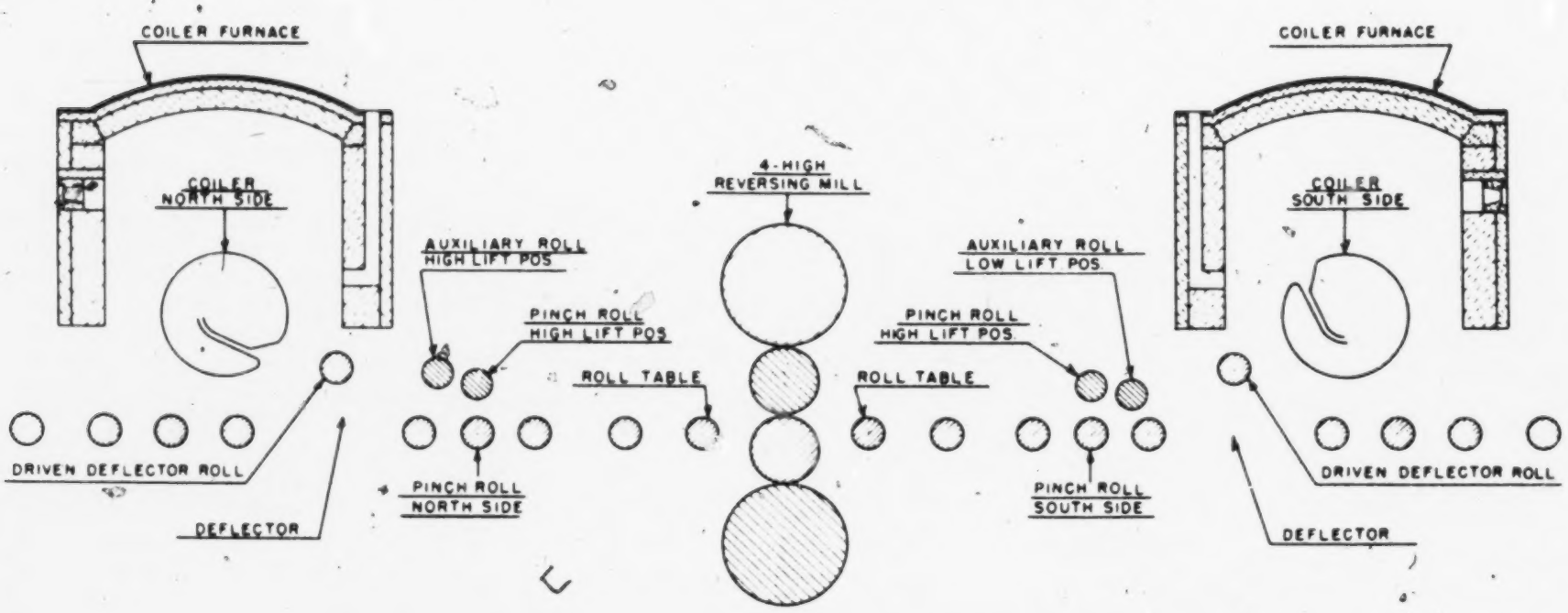


FOURTH PASS STARTED

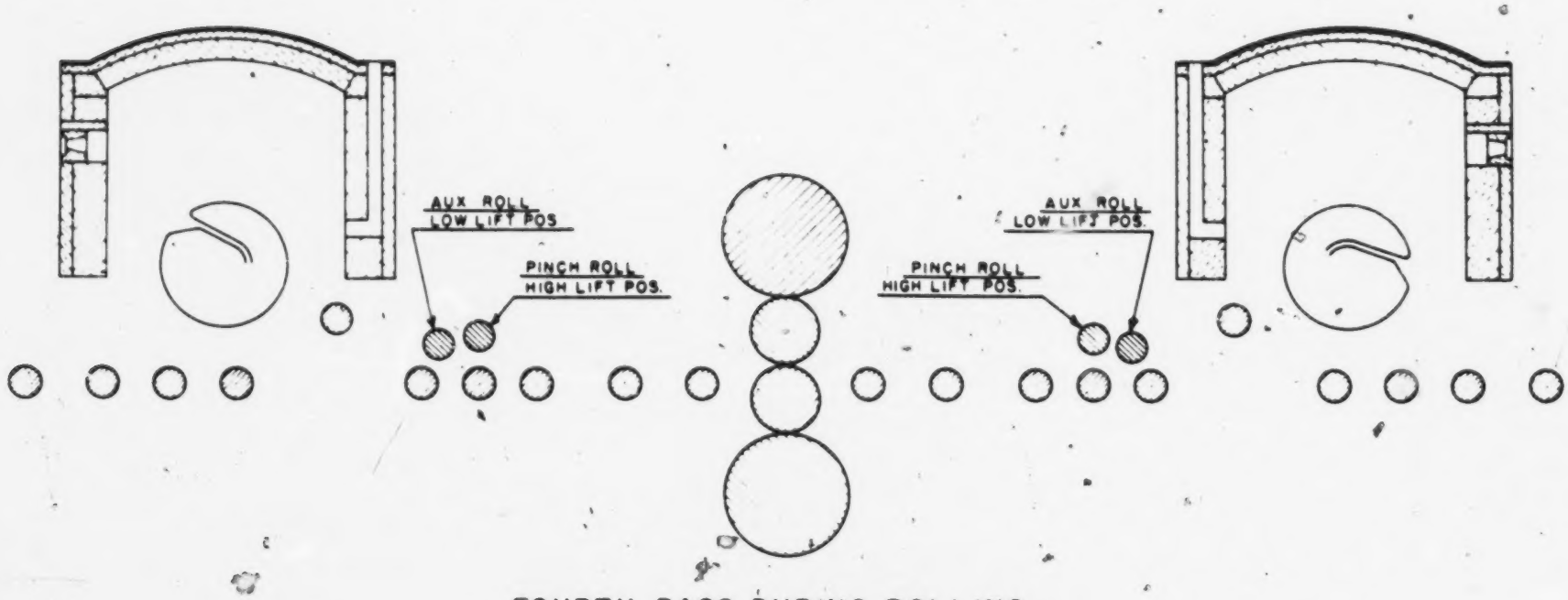
DWG. No. 21

CRUCIBLE HOT STRIP MILL

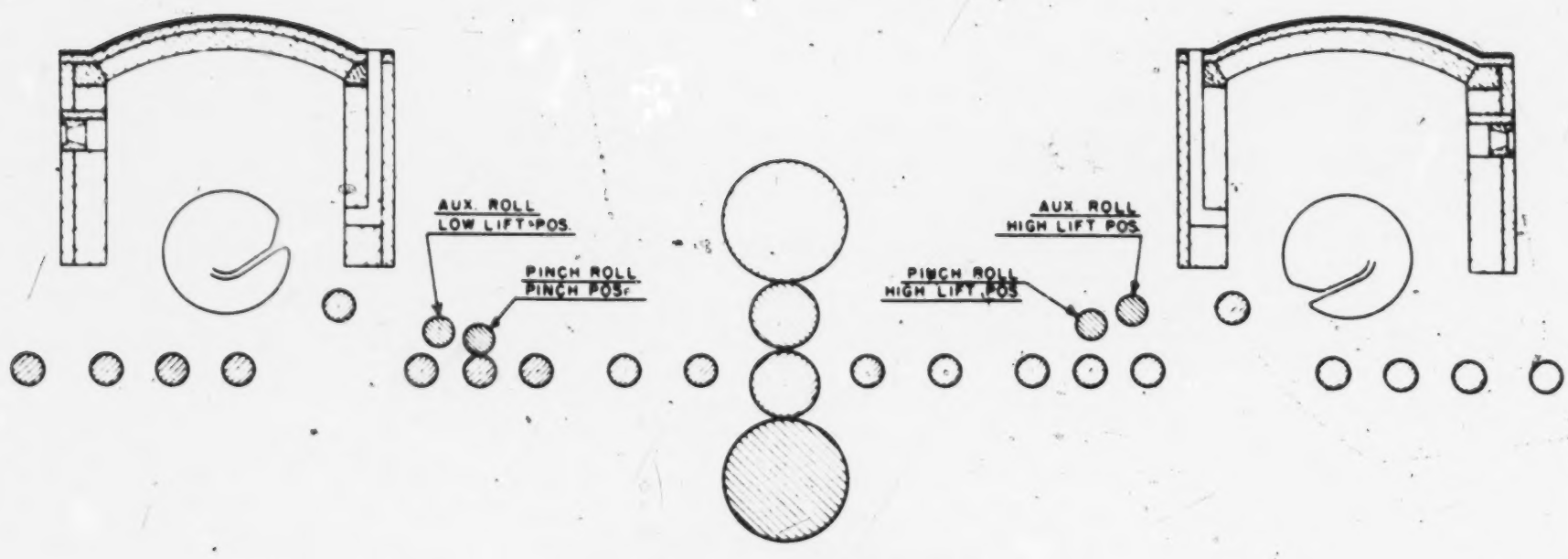
OPERATION OF MODIFIED MILL



FOURTH PASS-STRIP ENTERING COILER ON NORTH SIDE



FOURTH PASS DURING ROLLING

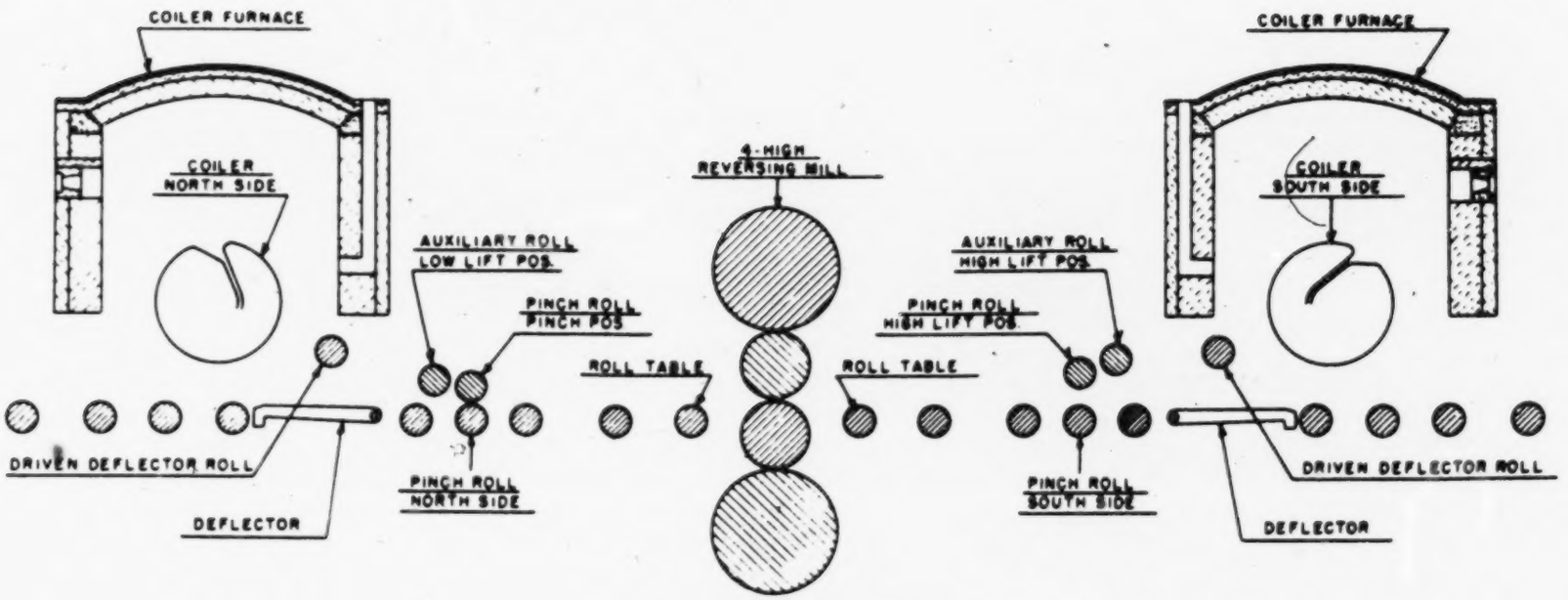


FOURTH PASS COMPLETED

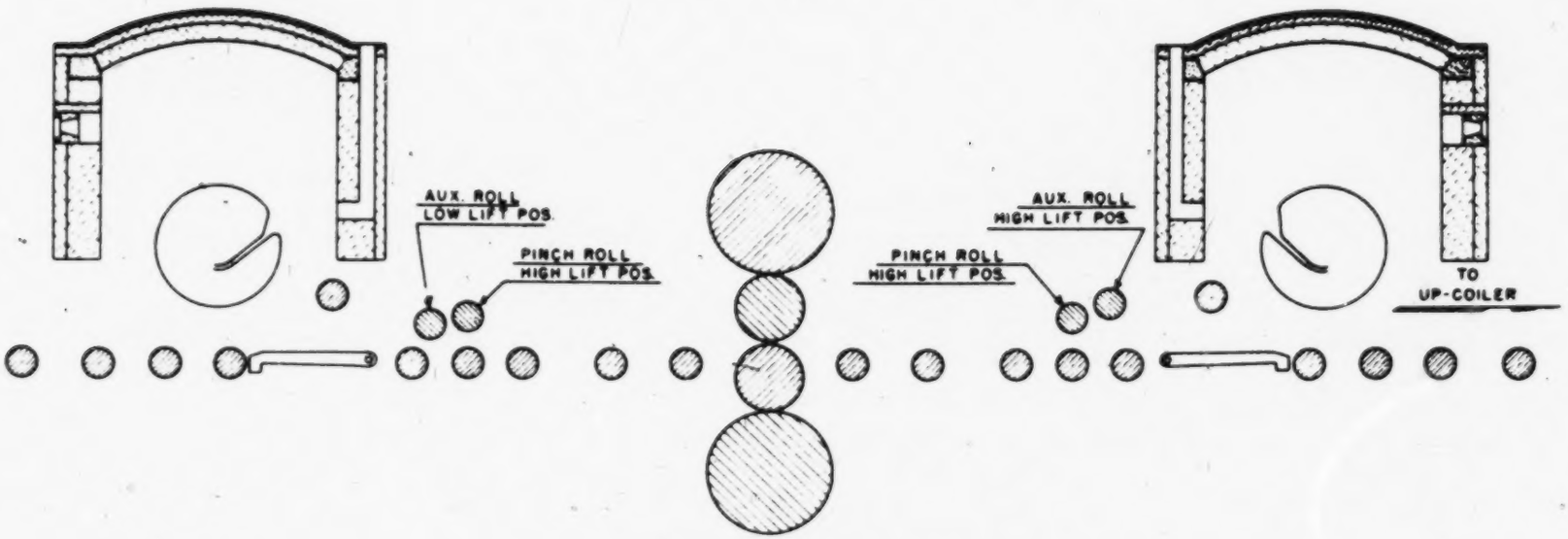
DWG. No. 22

CRUCIBLE HOT STRIP MILL

OPERATION OF MODIFIED MILL



FINAL PASS STARTED

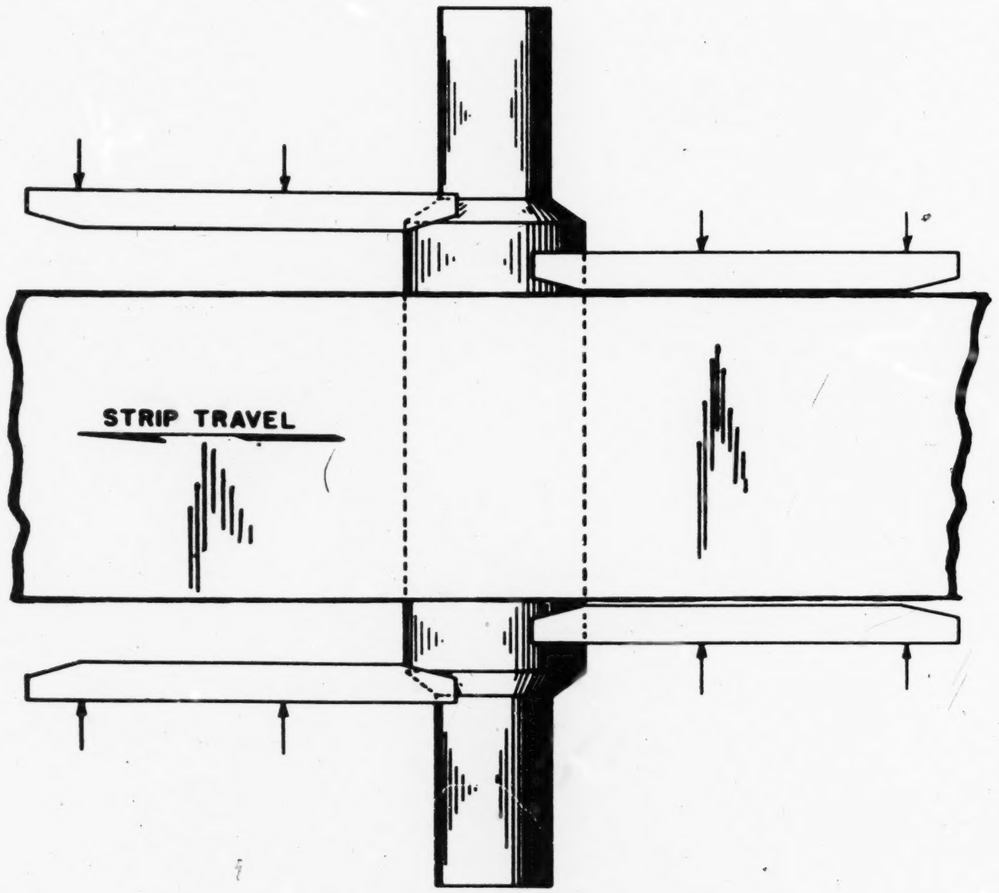


FINAL PASS DURING ROLLING

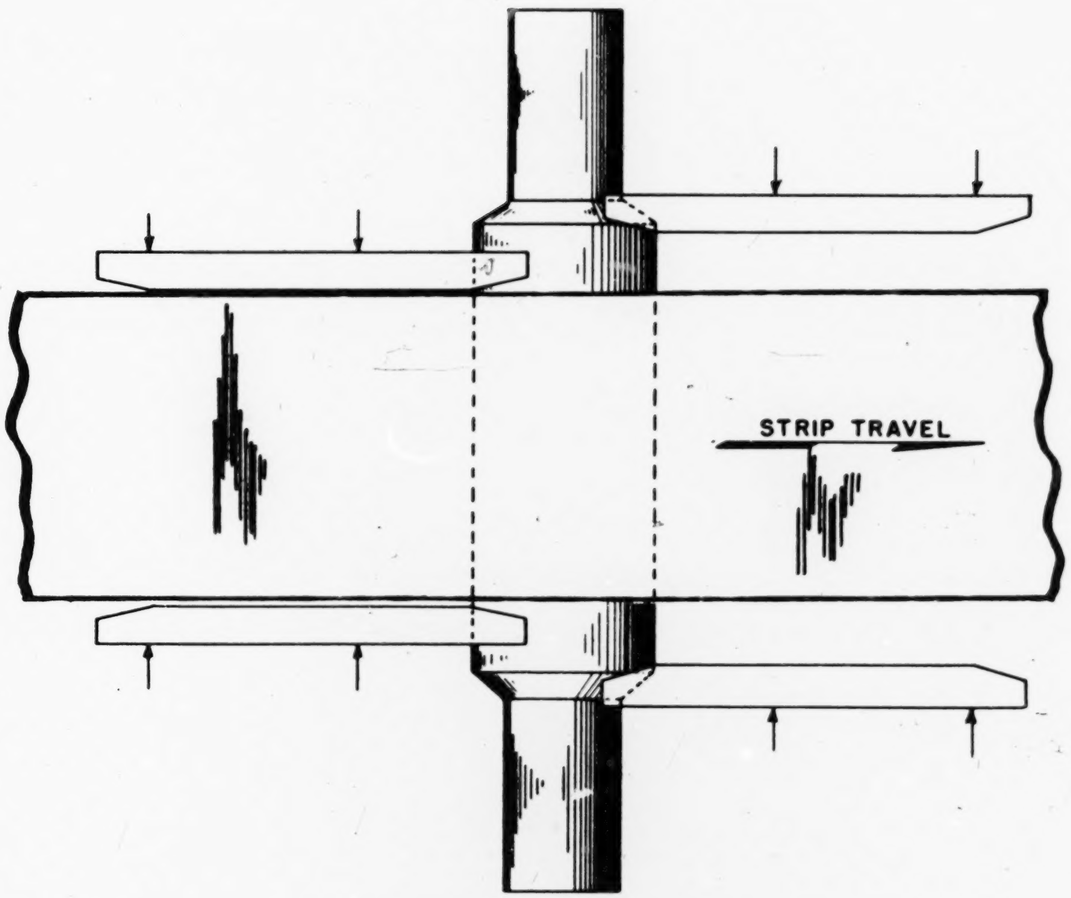
DWG. No. 23

CRUCIBLE HOT STRIP MILL

SIDE GUIDE POSITIONS DIAGRAMMATICALLY ILLUSTRATED



THREADING & RUNNING POSITIONS
TRAVEL TO LEFT



THREADING & RUNNING POSITIONS
TRAVEL TO RIGHT

Defendant's Exhibit D-4.

C. B. CUSHWA.

METHOD OF ROLLING SHEET METAL.

APPLICATION FILED AUG. 18, 1905.

904,605. Patented Nov. 24, 1908

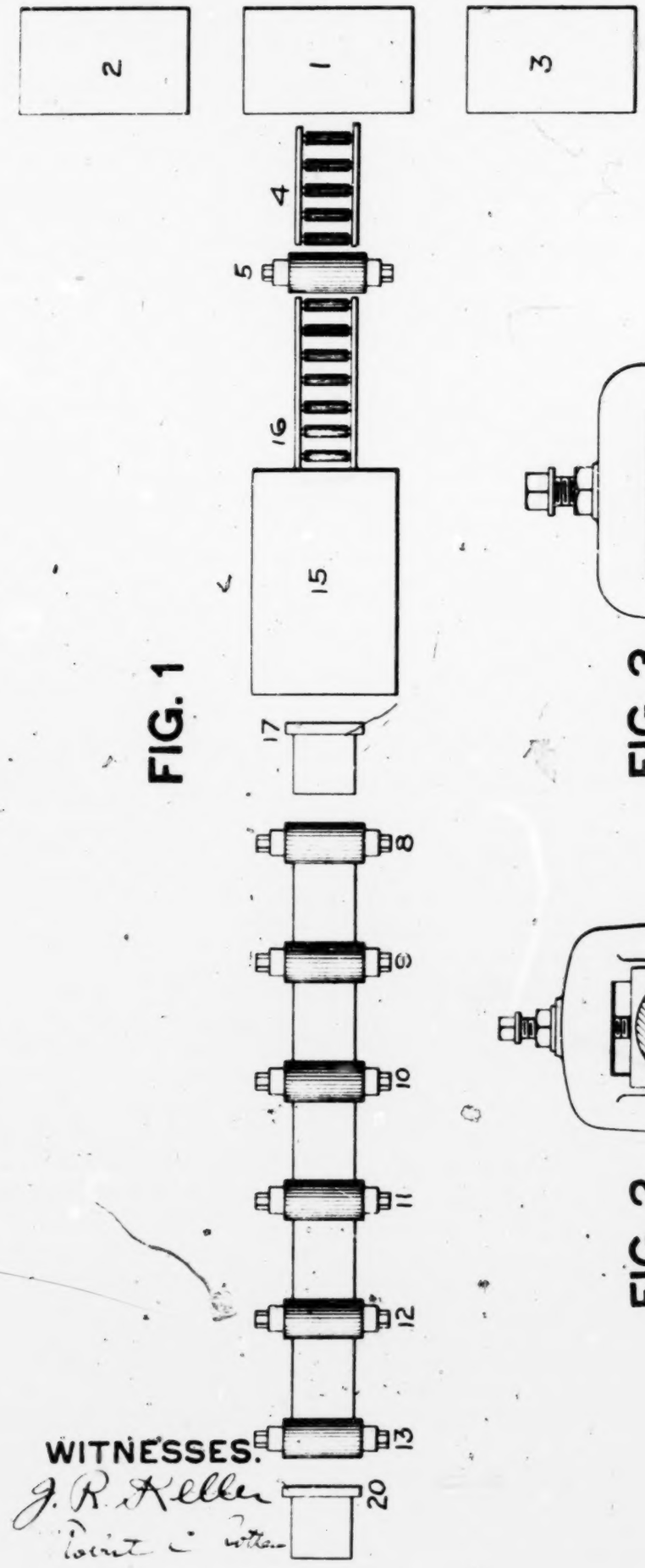


FIG. 1

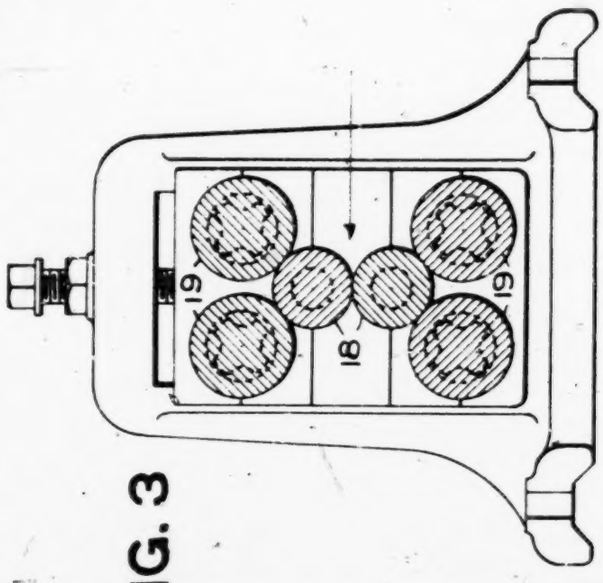


FIG. 3

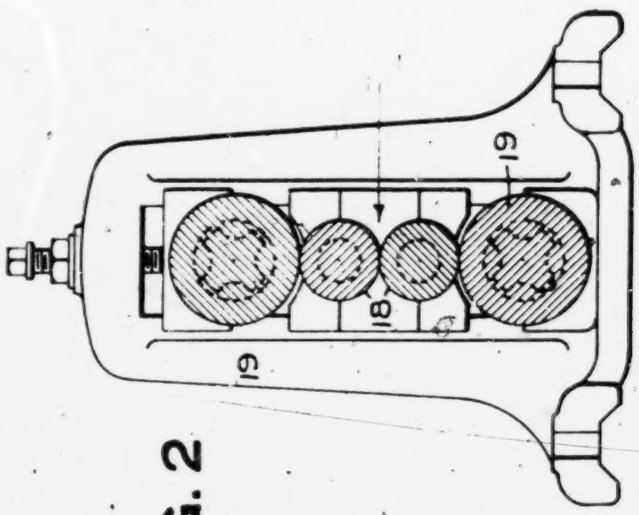


FIG. 2

WITNESSES.

J. R. Kelber

Robert C. Potter

INVENTOR.

Charles B. Cushwa

By Roy Potter & Watts

Attorneys

UNITED STATES PATENT OFFICE

CHARLES B. CUSHWA, OF YOUNGSTOWN, OHIO.

METHOD OF ROLLING SHEET METAL.

No. 904,605. Specification of Letters Patent. Patented Nov. 24, 1908.

Application filed August 18, 1905. Serial No. 274,726.

To all whom it may concern:

Be it known that I, CHARLES B. CUSHWA, a resident of Youngstown, in the county of Mahoning and State of Ohio, have invented a new and useful Improvement in Methods of Rolling Sheet Metal; and I do hereby declare the following to be a full, clear, and exact description thereof.

My invention relates to a method of rolling metal in the form of thin sheets or strips, and its object is to provide a method whereby the many reheatings and the many manipulations and handlings of the metal employed in ordinary processes are dispensed with, thereby greatly reducing the cost of production; one wherein the amount of scrap produced is very largely reduced, and one wherein both faces of the sheet are subjected to the action of rolls, thus giving a bright and smooth surface on both sides.

The most commonly employed process of producing sheet and similar metal is to start with a sheet bar which is about $\frac{3}{8}$ to $\frac{3}{4}$ of an inch in thickness, and 5 to 8 inches wide, and of a length approximately equal to the width of sheets to be formed. These sheet bars are heated and reduced in breaking down rolls, which are ordinarily 2-high rolls through which the plate is fed a number of times. Two or more sheets thus formed are then piled one on the other and rolled down to about 18 to 20 gage. These sheets are then separated or opened up and again piled and reheated to a good rolling temperature and then further reduced. For the coarser gages this is generally sufficient, but for the finer gages the packs are doubled one or more times, again reheated and further reduced. This old hand process requires a large amount of labor and repeated reheatings, thus adding considerably to the cost of production. It also results in the production of a large amount of scrap, this being due to the fact that when piled the sheets do not stay in exact position but slip sidewise or endwise and thus result in producing edge portions which are of unequal thickness. If the edges are very thin they do not elongate in the further reduction but are caused to crack. All of these cracked and unequal edges must be sheared off. Furthermore, it is not possible to handle long packs by hand, and owing to the tendency of the sheets to separate and slip they are rolled mostly in lengths from 8 to 10 feet long. At each end of these sheets there is from 6 to 10 inches of scrap which must be sheared off. Furthermore, in rolling the sheets in packs only one side of the two outside sheets of the pack are subjected to the action of the rolls. These receive a bright and smooth finish. All of the other faces being in contact have a rough, duller finish, so that it is necessary to finish by cold rolling the sheets separately.

It has been proposed to roll sheets by running the packs or piles through continuous or tandem mills. This has the advantage over the old hand process of reducing the amount of labor and the number of reheatings. The sheets, however, are packed or piled and therefore the amount of scrap produced is equal to that of the old hand process, and the sheets also must be cold rolled in order to finish the same.

The object of my invention is a method of rolling sheets, strips and other thin metal, in which the above defects and objections are overcome.

It consists, generally stated, in starting with an ingot, billet or slab, roughing the same down to approximately $\frac{1}{2}$ inch or less in thickness, and then while still at the same heat passing the plates so produced singly through tandem mills consisting of a sufficient number of stands of small sized rolls to reduce the same to finished gage. As a consequence labor and reheatings are largely overcome, both faces of the sheet are of the same bright, smooth finish, thus dispensing with cold rolling to finish, and the finished sheet is of very long length, producing scrap only at its two ends, and the side edges being of the same thickness as the body and not cracked, so that only very little metal need be sheared off and the amount of scrap is reduced to a minimum.

In the accompanying drawing Figure 1 shows in diagram apparatus suitable for carrying out my process; and Figs. 2 and 3 are sectional views of suitable rolls for the tandem mill.

1, 2 and 3 represent suitable heating furnaces wherein the ingot, billet or slab is heated to a suitable rolling temperature. From these furnaces the heated ingot, billet or slab is transferred to the feed table 4 of the roughing down mill 5. The latter can be either a 2-high reversing mill or a 3-high mill. The heated ingot, billet or slab is

passed back and forth through the mill 5 in well understood manner until it is reduced to a plate of approximately the width of the sheet to be formed and from about one quarter to a half inch thick.

The ingot, billet or slab is much cheaper to produce than the sheet bars heretofore necessary. Furthermore, it can be roughed to the gage specified at a single heat, and its gage is still such that the plate holds sufficient heat to enable it to be reduced to finished gage in the tandem or continuous mills represented by the rolls 8, 9, 10, 11, 12 and 13. To guard against delays on these finishing rolls I prefer to run the plate as it emerges from the mill 5 into a furnace 15, suitable live rolls 16 being employed to convey the plate through said furnace. In this furnace the plate, if delayed, is maintained at a good rolling heat, even though it be delayed a considerable time before entering the finishing mill. A shear 17 is provided for clipping off the front ragged end of the plate before entering the finishing mill. The finishing mill is shown as composed of six stands of rolls arranged in tandem, but the number thereof may be greater or less than this number, and in any event will be sufficient to reduce the plate to the finished gage.

The tandem mills are of the form shown in Figs. 2 and 3 in which the reducing rolls 18 are of comparatively small diameter. In order to give these small sized rolls sufficient stiffness each is backed by one or two large rolls 19, Fig. 2 showing one such backing roll and Fig. 3 showing two. The small sized rolls 18 have only a small area of contact with the metal being reduced, hence they press more deeply into, and more rapidly reduce or stretch the metal, than do the large diameter rolls usually employed in sheet mills. The small area of contact between such rolls and the plate also has the effect of reducing the amount of heat absorbed from the plate so that the latter is maintained at a better rolling heat than if larger rolls were used. The plate, after being roughed down is still very close to the initial heat of the blank, that is, a good bright red heat, and the further reduction thereof in the tandem mill described is effected so rapidly and with such a small absorption of heat by the rolls, that the plate reaches practically the thinnest gages before the temperature falls below a dull red.

By my process I start with ingots, billets or slabs, which are cheap compared to the usual plate bar, and reduce them to finished gage and without piling or folding the partially reduced sheets, and substantially at the initial heat. The plate emerging from the finishing rolls is very long and its edges are only slightly irregular. As a consequence the amount of scrap is very small. After leaving the mill the plate is cut to finished size by shears 20.

The labor necessary to carry out my process is reduced to a minimum, and as reheatings are practically dispensed with there is also a great saving of fuel. Furthermore, each sheet is finished separately so that both faces are acted on by the rolls and consequently have a bright smooth finish, thus dispensing with cold rolling to finish. As a consequence the process is very economical.

In case the metal is to be formed as strips it can be either rolled in narrow widths or else passed through suitable slitting shears after emerging from the finishing rolls.

What I claim is:

1. The method of rolling sheet metal, which consists in heating a suitable blank, and without further heating reducing the same to 20 gage United States standard, or thinner, by subjecting the same to successive rolling actions applied to small areas equally on both sides of the plate, thereby effecting the reduction at a temperature not less than a good dull red.

2. The method of rolling metal sheets, strips and the like, which consists in heating an ingot, billet, or slab, reducing the same by rolling and without further heating to a plate approximately $\frac{1}{4}$ to $\frac{1}{2}$ inch thick, and then at the same heat reducing the same to finished gage by subjecting the same to successive rolling actions applied to small areas equally on both sides of the plate.

In testimony whereof, I, the said CHARLES B. CUSHWA have hereunto set my hand.

CHAS. B. CUSHWA.

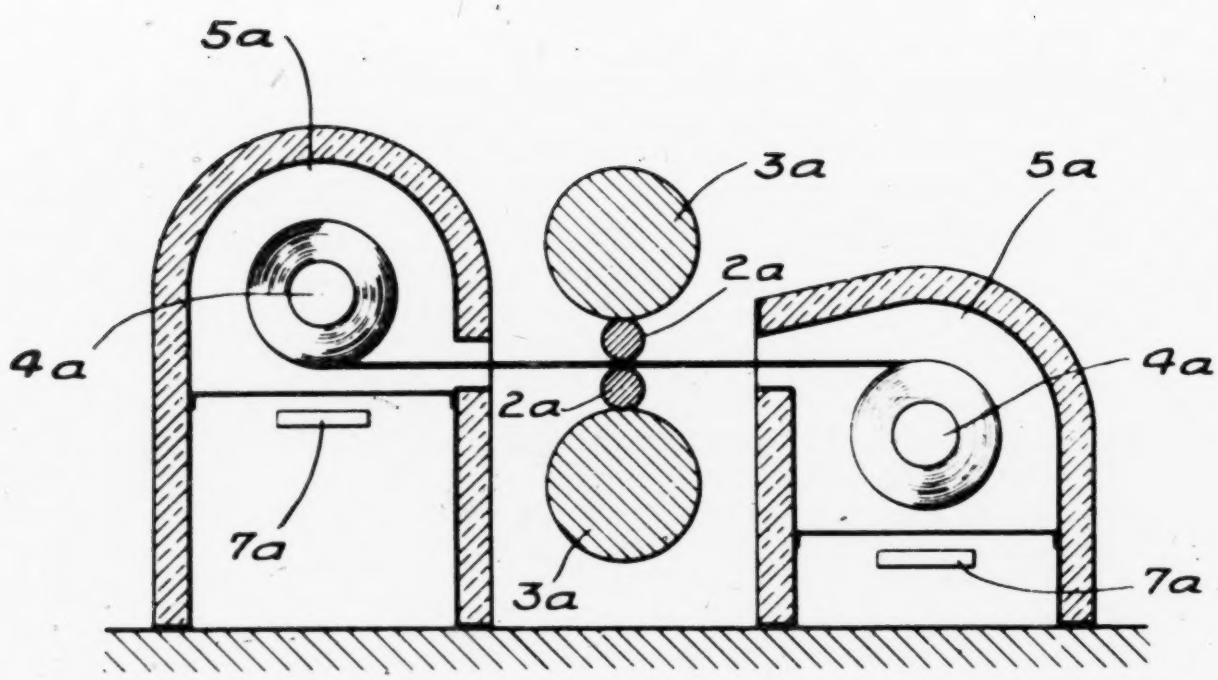
Witnesses:
F. W. WINTER,
ROBERT C. TOTTEN.

Defendant's Exhibit D-13-A.

May 10, 1932. A. P. STECKEL **1,857,670**

ROLLING METAL STRIP

Filed June 15. 1927



INVENTOR
A. P. Steckel
by his attys,
Byron, Stebbins & Pamela

Patented May 10, 1932 1,857,670

UNITED STATES PATENT OFFICE

ABRAM P. STECKEL, OF YOUNGSTOWN, OHIO, ASSIGNOR TO THE COLD METAL PROCESS COMPANY, OF YOUNGSTOWN, OHIO, A CORPORATION OF OHIO

ROLLING METAL STRIP

Application filed June 15, 1927. Serial No. 198,915.

This invention relates to the rolling of metal strip and particularly to the hot rolling thereof. The term strip is herein employed to define an extended length of metal in sheet form regardless of its width.

Metal strip is now being rolled in continuous mills, but these mills are so large and occupy so much space that a very heavy capital outlay is required. The operating cost of the continuous mill is high because of the large amount of power required.

An older method of making strip material is to employ a single reversing stand and to run the metal out on a roll table to either side of the stand. This method is undesirable because as the metal is reduced to the thinner gauges it rapidly loses heat.

I provide for subjecting a piece of heated metal to a plurality of roll passes and coiling the metal between passes. This reduces the radiating surface to a minimum and permits of rolling for long periods of time without reheating. It also makes it possible to materially reduce the cost of the installation since the long run-out tables are unnecessary. It will be understood that roll tables may be employed for effecting some of the preliminary reductions, but these will not need to be of anything like the length which would be required for the final product. I may place the coilers in heat conserving chambers, one on either side of the mill. These chambers may be arranged so as to be moved sidewise and thus permit of rolling a slab in the ordinary way down to such thickness that it can be coiled.

Another advantage of the coilers lies in the fact that they are effective for scaling the metal. I arrange the coilers so that the metal is curled first in one direction and then in the other, so that the scale is cleaned from both sides.

The accompanying figure of drawing illustrates my invention diagrammatically. It shows a reversing mill comprising a pair of working rolls 2*a*, each provided with backing up rolls 3*a*. Either the working rolls or the backing up rolls may be driven, as desired. The mill is provided with the usual screw-downs so that successive reductions may be made.

Coilers 4*a* are provided on either side of the mill, these being arranged to reel or to pay out material depending on which way the mill is running. Each coiler is motor driven and may be operated at such a rate as to maintain the delivered strip under tension. Each coiler is contained in a heat conserving chamber 5*a* having suitable doors, not shown, to permit of removing a coil of material. Each chamber is provided with heating means 7*a* to maintain it at the proper temperature. Once the chambers are hot and the device is in operation, very little heat will be required beyond that supplied by the metal itself.

In operation a heated slab will be rolled in the ordinary way until it is thin enough to coil. The coiled material is supplied to the mill and fed from one reel through the mill and thence to the other reel. On the next succeeding pass the operation will be reversed, the paid out material being fed back through the mill to the first coiler. The heat loss will be very slight as compared with ordinary rolling practice due to the very small radiating surface presented by the coil and also due to the conservation of heat by the chamber 5*a*.

It will be noted that the material is flexed first in one direction and then in the other. This effects removal of the scale from the strip.

While I have illustrated a preferred embodiment of my invention, it will be understood that the invention is not thus limited, as it may be otherwise practiced or embodied within the scope of the following claims:—

I claim:—

1. The method of rolling metal strip which includes coiling a strip of hot metal in a heating chamber, uncoiling the same and feeding it from the chamber through a roll pass and to another heated chamber, coiling the strip therein in a direction opposite to that in which it was first coiled, and periodically reversing the direction of rolling.

2. The method of rolling metal strip which includes coiling a strip of hot metal in a heating chamber, uncoiling the same and

feeding it from the chamber through a roll pass and to another heated chamber, coiling the strip therein in a direction opposite to that in which it was first coiled, periodically reversing the direction of rolling, and maintaining the metal under tension between the rolling thereof and the coiling thereof.

3. The method of rolling strip metal which includes coiling a strip of hot metal in a heating chamber, uncoiling the same and feeding it from the chamber through a roll pass and to another heated chamber, coiling the strip therein, periodically reversing the direction of rolling so that the material is fed back and forth from one coil to another, and subjecting the material to bending in both directions so as to effect removal of scale.

In testimony whereof I have hereunto set my hand.

ABRAM P. STECKEL.

July 18, 1933. R. M. KEENEY ET AL 1,918,968

ROLLING MILL

Filed Jan. 12, 1928 3 Sheets-Sheet 1

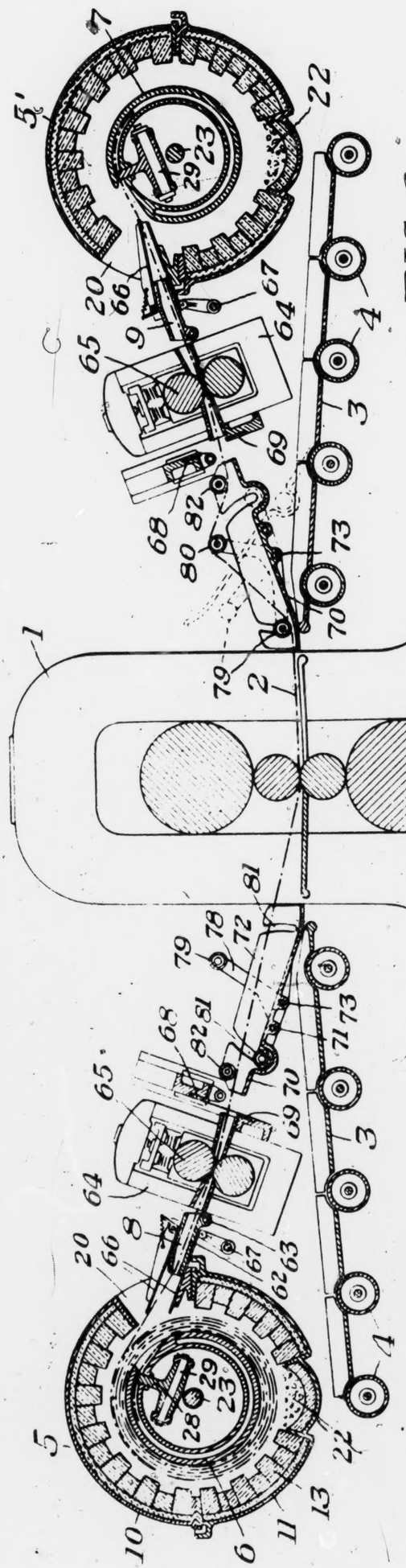


FIG. 1.

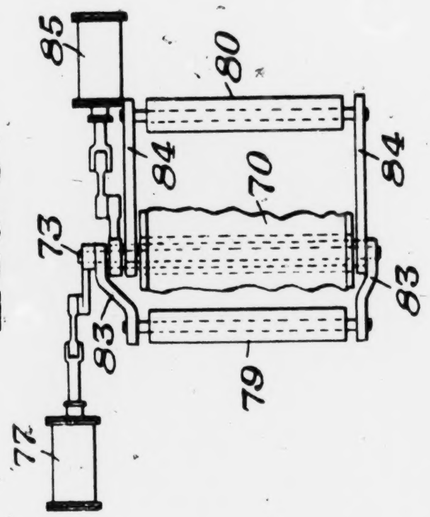


FIG. 6.

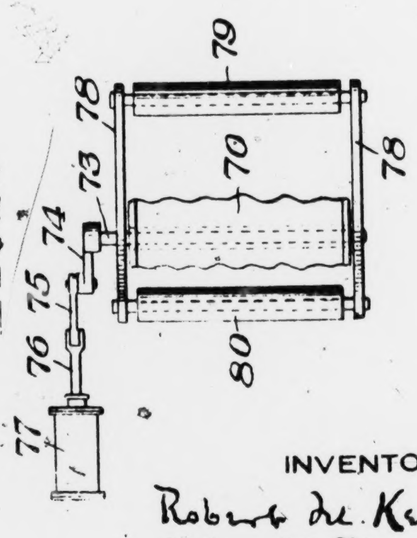


FIG. 5.

INVENTORS

Robert M. Keeney

John F. Ferm,

by Christy & Christy

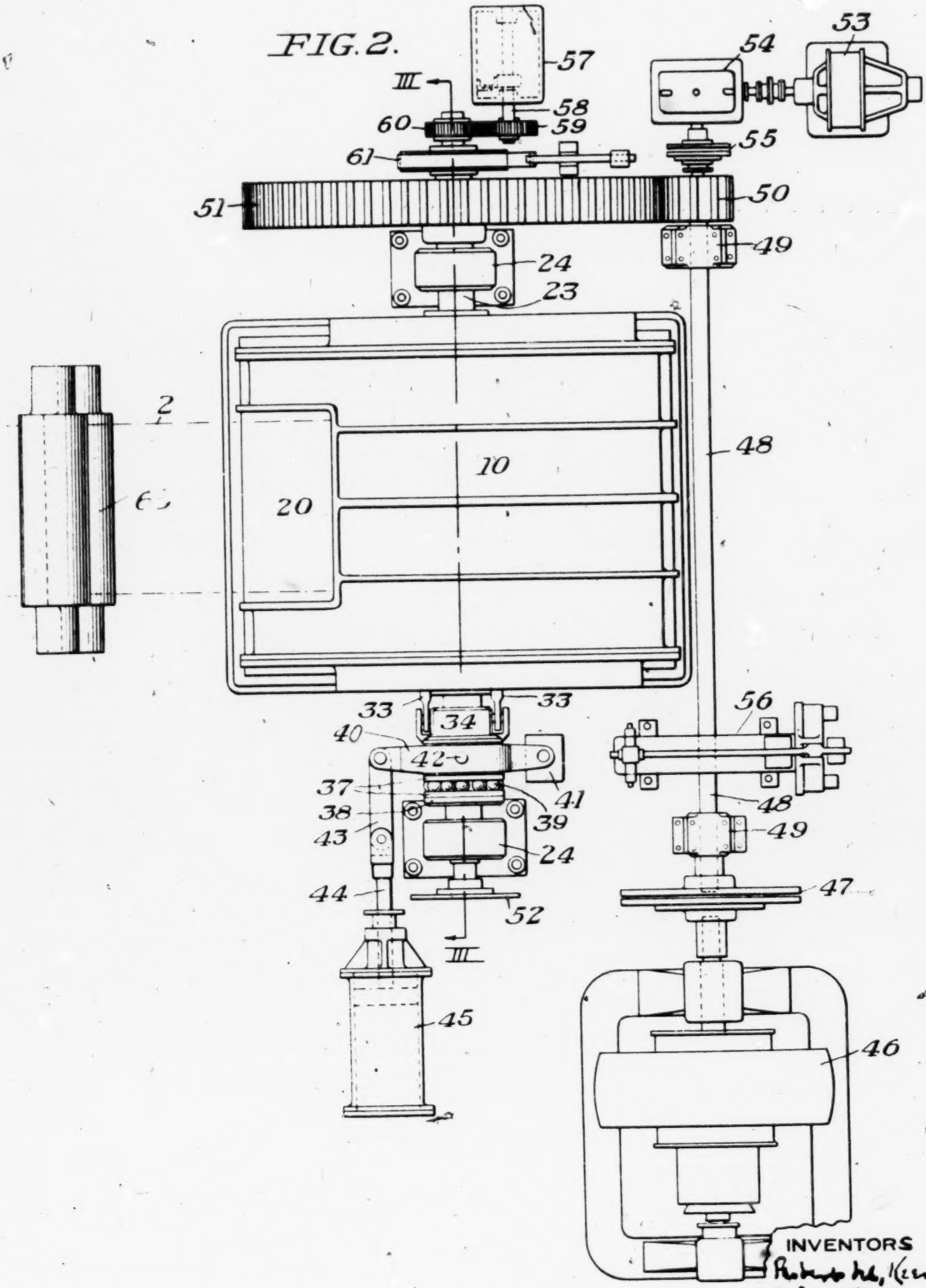
Attys.

July 18, 1933. R. M. KEENEY ET AL 1,918,968

ROLLING MILL

Filed Jan. 12, 1928 3 Sheets-Sheet 2

FIG. 2.



INVENTORS
Robert M. Keeney
John F. Irons
by Christy & Christy
Attys.

July 18, 1933. R. M. KEENEY ET AL 1,918,968

ROLLING MILL

Filed Jan. 12, 1928 3 Sheets-Sheet 3

FIG. 3.

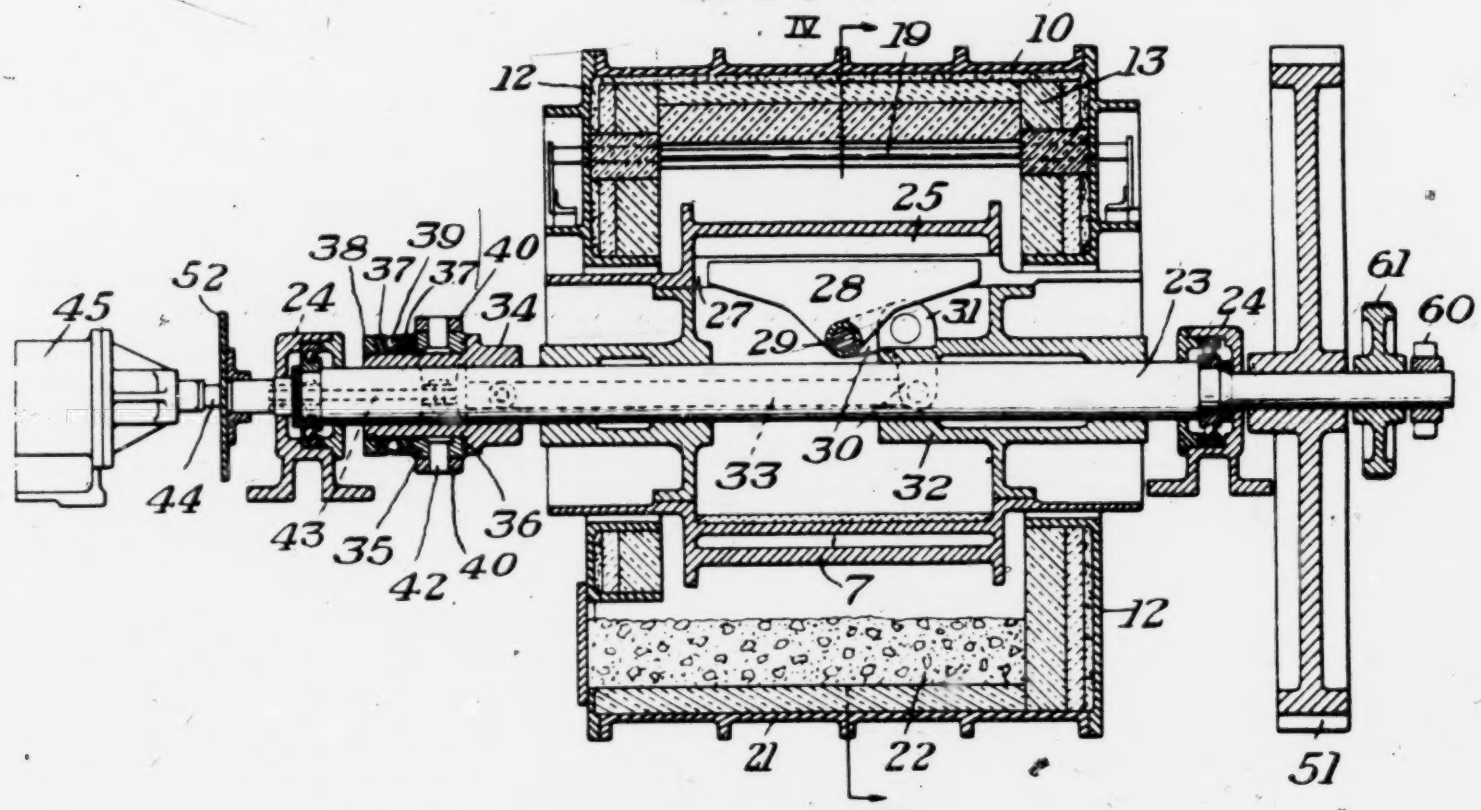
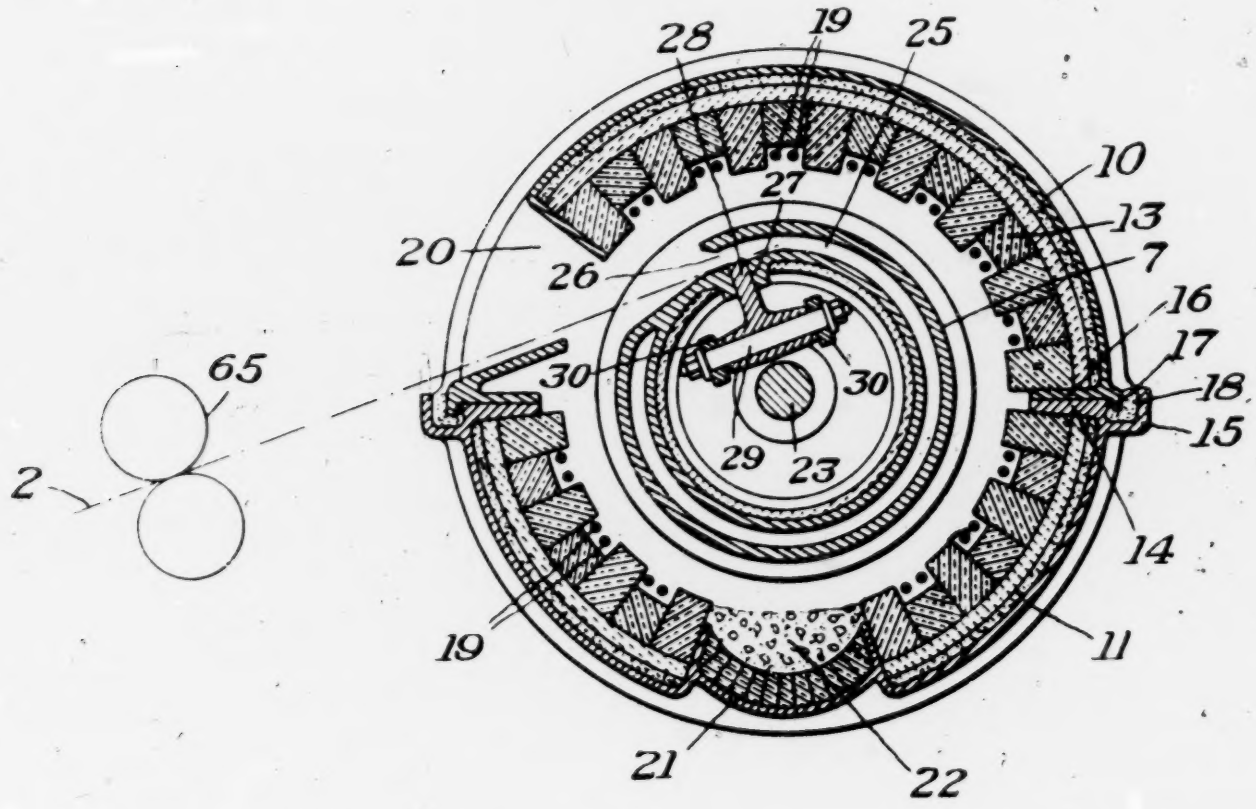


FIG. 4.



INVENTORS

Robert M. Keeney

John F. Ferree

by Christy & Christy

Attys

Patented July 18, 1933 1,918,968

UNITED STATES PATENT OFFICE

ROBERT M. KEENEY AND JOHN F. FERM, OF MIDLAND, PENNSYLVANIA

ROLLING MILL

Application filed January 12, 1928. Serial No. 246,181.

This invention relates to the rolling of metal in strip-like form and while, as herein described, it is particularly applicable to the hot rolling of iron or steel strips or strip sheets of light gauge and great length, it is also applicable in certain of its aspects to the cold rolling of metal in strip-like form. In the manufacture of sheet steel it has been proposed, and in some cases practiced, to supersede the old and common methods of finishing comparatively short lengths of rough-rolled sheets by matching and doubling, by rolling wide and long sheets in a continuous mill. Not only does this require a mill of great length and very accurate relative adjustment of the passes through the successive stands of rolls, but the strip in the process of reduction and elongation loses heat so rapidly that the manufacture of the lighter gauges of sheets in this way has been economically impracticable. It is the primary object of the present invention to provide means whereby long and thin strips can be heated effectively and economically during the process of rolling, and therefore can be reduced to any thinness attainable by hot rolling, and the entire operation, after the initial roughing-down, can, if desired, be carried out in a single stand of rolls.

In the accompanying drawings Figure 1 is a view in longitudinal sectional elevation of the finishing rolls of a strip mill having combined therewith mechanism embodying the present invention. Figure 2 is a plan view of one of the coilers and its operating mechanism. Figure 3 is a section of the coiler on the line III—III of Figure 2. Figure 4 is a cross-section on the line IV—IV of Figure 3. Figures 5 and 6 show alternative means for maintaining tension upon the strip.

The stand of rolls 1 is shown only conventionally, and it will be understood that suitable means for adjustment of the rolls, and other proper accessories, will be employed. The strip being rolled is designated by the broken line 2. The usual feed-tables 3 having driven rollers 4 are shown on the opposite sides of the stand of rolls 1.

Above the tables and the roll-pass and on opposite sides of the stand of rolls 1 are suitably supported heating-furnaces or chambers 5 and 5′, within which are rotatably mounted reels or drums 6 and 7, and from which the inclined chutes 8 and 9 (to be hereinafter described) lead down to the roll-pass. As shown in Figures 3 and 4, each of the heating furnaces comprises upper and lower semi-cylindrical metallic shells 10 and 11, having closed end walls 12, and lined with refractory 13. The lower shell 11 has an inner flange portion 14 at its top and an outer cup portion 15, and the upper shell 10 has an inner flange portion 16 which rests on the flange 14, and an outer downwardly bent lip 17 which projects into the cup 15, where the joint is packed with loose refractory 18. By reason of this construction the upper half of the furnace may be lifted off the lower half by means of a hoisting crane whenever desired. The resistors 19 are suitably arranged and mounted within the heating chamber for the electrical generation of heat. The transverse opening 20 is formed in the upper shell 10 for the passage of the strip being rolled. I term each heating furnace and reel, with their accessories, collectively a coiler. A trough or basin 21 may be formed in the bottom of the lower shell 11, and be filled with a substance having a greater affinity for oxygen than has the metal strip being rolled, such as coal-dust, coke or charcoal 22, so as to protect the strip from injurious scaling.

Each reel or drum 6 and 7 is mounted upon a driving shaft 23 which projects out through suitable openings in the opposite end walls 12 of the heating chamber and is supported in bearings 24. The reel has a transverse slot 25 in its wall adapted to receive the advance end of the strip being rolled, the entrance opening 26 of which is shown in Figure 4 as standing adjacent to the opening 20 in the wall of the coiler. A second transverse slot 27 through the inner wall of the slot 25 near its entrance end connects the slot 25 with the inner open body of the reel, and in this slot 27 works the locking-bar 28, adapted when projected outwardly to bind the advance portion of the strip being rolled against the opposite wall of the slot 25 and thus lock the strip to the reel in the coiler. At its inner end

the bar 28 carries a stub shaft 29, the opposite ends of which are connected to the horizontal arms of rocking-levers 30 pivoted to small standards 31 supported on one of the hubs 32 of the reel, on opposite sides of the driving-shaft 23. The lower ends of the vertical arms of the levers 30 are connected by links 33 to the sleeve 34, which rotates with but can slide upon the shaft 23. A collar 35 is mounted upon the sleeve 34 between an inner shoulder 36 on the sleeve and the rings 37 held in place by a nut 38 screwed upon the outer end of the sleeve. Anti-friction balls 39 are interposed between the rings 37. A bifurcated lever 40, pivoted at one end to the standard 41, is connected at its central points by pins 42 to the collar 35, and at its opposite end is loosely connected by link 43 to the piston-rod 44 of the motor-cylinder 45. Thus by operating the piston in the cylinder 45, the bar 28 will be advanced and retracted to lock and release the end of the strip being rolled.

Mechanism suitable for driving the reel to wind up the strip as it comes from the rolls is also shown in Figure 2. The shaft of the motor 46 is connected by a magnetic clutch 47 to the end of the shaft 48 supported in bearings on the standards 49. At its opposite end shaft 48 has fastened to it the pinion 50 which meshes with and drives the gear wheel 51 which is fastened upon the driving-shaft 23 of the reel. At its projecting opposite end the shaft 23 may carry any suitable indicating device 52, such for example as a pointer, to show the position of the reel within the coiler, and particularly when it is in the proper position to receive the advance end of the strip being rolled, as shown in Figure 4. A separate slow drive is employed for turning the empty reel to the strip-receiving position shown in Figure 4, after the motor has been stopped and the magnetic clutch 47 (which is in the motor-operating circuit) has been opened. A separate motor 53 operates a worm and worm-wheel in the casing 54, the worm-wheel carrying a short shaft connected by a magnetic clutch 55 with the end of the shaft 48, as also shown in Figure 2.

In the unwinding of the reel 6 or 7, when the circuit of motor 46 will be broken and the clutch 47 open, it is desirable that the reverse rotation of the reel shall be stopped (and the trailing end of the strip be released) shortly before the strip is wholly withdrawn from the coiler. For that purpose we provide a magnetic brake 56 for the shaft 48, the operation of the brake being controlled by a limit switch in the box 57, and the switch being operated by a shaft 58 having a pinion 59 meshing with a pinion 60 on the end of the reel-shaft 23. Electrical apparatus of this character is well known to those skilled in the art, and detailed description of any of several forms which may be used is therefore unnecessary. The switch is so organized that it will cause the brake 56 to act upon the shaft 48 preferably when the reel has still one complete unwinding revolution to make, and we calculate that the reel will be completely stopped in a half of a revolution more. The trailing end of the strip having been by that time released by withdrawal of the bar 28, the balance of the strip will be free to be drawn out of the coiler. The brake 56 will then be opened and the motor 53 operated to turn the reel to the strip-receiving position shown in Figure 4.

To act as a drag upon the reel during unwinding we provide a band-brake 61 of common form for the shaft 23, having its free end counterweighted, so as to operate only when the shaft is turning in the unwinding direction. This brake is shown in Figures 2 and 3.

At the top of each of the chutes 8 and 9 there is arranged a guide comprising a rear section 62 pivoted at 63 to a bracket or brackets on the housing 64 of pinch-rolls 65 to be mentioned presently and resting upon the lower lip of the entrance 20 into the coiler, and an outer telescopic section 66 which is connected to a rock-shaft 67, and may be moved forwardly and backwardly by turning the rock-shaft by any suitable means. Thus the tip of the section 66 may be projected in close to the reel, as shown at the right-hand side of Figure 1, or it may be drawn back out of the way of the coils on the reel, as shown at the left-hand side.

The pinch-rolls 65, adjustably mounted in the housings 64, are located in the chutes 8 and 9 to feed the strip alternately to the coiler and back to the stand of rolls 1. These pinch-rolls may be driven by any suitable mechanism, but preferably by an electric motor, including in the motor-operating circuit a magnetic clutch operating in the same way as the clutch 47. Adjacent to and immediately below the pinch-rolls is a shear comprising a movable blade 68 and a fixed blade 69.

Below the shear and extending into proximity to the stand of rolls 1 each of the chutes 8 and 9 has a tilting section 70 centrally mounted upon a rock-shaft 71. This tilting section has a floor and preferably opposite side walls 72. The tilting sections are provided so that they may be swung to a horizontal position, on one side of the rolls 1 to admit the strip coming from the roughing rolls of the mill, and on the other side to deliver the finished strip. Or if desired both sections may be swung out of the way and the strip be given one or more passes through the rolls 1 before it enters the chutes and coilers. Also by tilting either section to the position shown in dotted lines at the right-hand side of Figure 1, any crop ends cut off by the shears can be delivered upon the roller

table 3 and disposed of without delaying the operation of the mill.

Means are provided for maintaining tension upon the strip in case it shall loop up between the rolls 1 and the pinch-rolls. Each tilting section carries beneath its floor a transverse rock-shaft 73, operated by a crank 74 at one end, which is connected by a link 75 with the piston-rod 76 of a fluid-pressure cylinder 77, as shown in Figure 5. Adjacent to the opposite ends of the shaft 73 are fastened the bent arms 78 carrying in their ends, respectively, the hubs of rollers 79 and 80, slots 81 being cut in the opposite side walls 72 to allow the passage of the hubs of the rollers as the arms 78 are rocked by means of the described connections. In the operation of the mill the strip on each side of the rolls 1 will pass under the roller 79 and over the roller 80. Tension is maintained yieldingly upon the looped strip, as shown in Figure 1, by means of the fluid-pressure cylinders, and the size of the loop aids the operator in adjusting the speed of rotation of the reel in the coiler to the speed of the reducing rolls. A bearing roller 82 is journaled in the opposite side walls 72 to maintain tension upon the looped strip, if necessary, on the upper side of the roller 80. If desired, the rollers 79 and 80 may be operated independently of each other, as shown in Figure 6. In such case the rollers 79 and 80 are mounted in the ends of independent arms, the arms 83 of the roller 79 being secured to the shaft 73 and operated by the cylinder 77 as in Figure 5, while the roller 80 is mounted in the ends of arms 84 fastened to a sleeve which surrounds the shaft 73, and which is connected to a second fluid-pressure cylinder 85.

In operation, assuming that the table 3 at the right-hand side of Figure 1 leads from the roughing mill, the roughed-down strip will be carried on this table into and through the initial pass between the reducing rolls 1, which also act to feed the strip up the chute at the left and between the pinch-rolls, which are being driven at that time and which feed the strip on into the coiler, the guide 62, 66 being in advanced position to direct the leading end of the strip into the slot 25 in the reel. As soon as the leading end of the strip enters the slot 25 it is locked by the bar 28, and the coiler-motor is started and the strip is wound on the reel, the pinch-roll motor being stopped and the driving-shaft disconnected by opening of its magnetic clutch, so that during the winding operation the pinch-rolls act as idle guide rollers. If during the rolling and winding operation the strip should loop up between the reducing rolls and the pinch-rolls, fluid pressure will be admitted to the cylinder 77 to maintain the proper yielding tension upon the strip by means of the roller 80 and the opposite flanking rollers 79 and 82, while the operator synchronizes as nearly as may be the winding speed with the speed of the reducing rolls. As soon as the trailing end of the strip passes the reducing rolls and before it reaches the pinch-rolls, the reel in the coiler is stopped and its motor disconnected from the drive shaft. The reducing rolls are then adjusted and started in the opposite direction, and the pinch-rolls are then driven in the opposite direction to feed the strip back through the reducing rolls, whence it goes to the coiler 5′ at the right-hand side of Figure 1, and is wound upon the reel 7 in the same manner as already described. During this reducing operation the pinch-rolls at the left turn idly, and the reducing rolls unwind the strip, the unwinding speed of the reel 6 being controlled by the drag-brake 61. When the last unwinding revolution of the reel 6 is reached, the locking-bar 28 is retracted and the brake 56 is automatically applied to the shaft 48. Thus the reel 6 is stopped, and the reducing rolls draw out the unlocked trailing end of the strip. Then the brake on the shaft 48 is released and the reel 6 is turned to receiving position by the motor 53. The strip may be given as many passes through the reducing rolls as may be desired, the rolls being adjusted between reductions by any of the well-known means, and since the strip is being repeatedly heated in the coilers, its proper rolling temperature will be maintained and it can be reduced to any thinness practicable by hot rolling. And since the strip while coiled loses its heat comparatively slowly, under some conditions the reducing operation may be performed without supplying heat to the coilers.

In efforts to roll single lengths of wide, very thin strip difficulties have been encountered in properly entering and delivering the strip into and from the reducing rolls. In the practice of the present invention such difficulties can be eliminated by making the final reducing passes while retaining the opposite ends of the strip in the opposite coilers, or at least back of the pinch-rolls, and shearing off the short unreduced opposite end portions, which will be only a negligible part of a long strip. In such case, after the final pass from left to right, the reducing rolls can be opened and the unreduced end drawn through and sheared off, and the finished strip then fed down onto the left-hand delivery-table 3 and the opposite end sheared off.

It will be noticed also that if the tilting sections of the chutes are turned to horizontal position, the mill with the opposite tables 3 may be used for rough rolling in the usual manner.

It is obvious that the coilers may be heated by the combustion of fuel instead of by electrically generated heat, and it is also the fact that many changes may be made in the structure and the various operating means here-

in shown and described without substantial departure from the invention as defined in the respective appended claims.

In the introductory part of this specification we have described this invention as particularly applicable to the hot rolling of iron or steel strips or strip sheets of light gauge and of great length. Heretofore in the art the term "strip" has been used to designate a long, thin piece of metal which is comparatively narrow, say of a maximum width of sixteen inches. Our invention is not limited to the manufacture of such pieces, but it is the intention to cover in the appended claims the manufacture of long, thin pieces of metal of any practicable width, and designated by us generally (whether narrow or wide) as thin metal strips.

We claim as our invention:

1. In a rolling-mill for the manufacture of hot-rolled thin metal strips, the combination with reducing rolls, of a pair of heating-chambers arranged one on each side of said rolls each having an opening for the passage of strip, means for supplying heat to each chamber, a winding-reel mounted in each chamber, means for guiding the strip from the rolls to each reel, means connected to each reel for alternately securing and releasing the strip, and means for operating each reel and winding the strip thereon.

2. In a rolling-mill for the manufacture of hot-rolled thin metal strips, the combination with reducing rolls, of a pair of heating-chambers arranged one on each side of said rolls each having an opening for the passage of the strip, means for supplying heat to each chamber, a winding-reel mounted in each chamber, means for guiding the strip from the rolls to each reel, means for securing the strip to each reel, means for operating each reel and winding the strip thereon, and means for returning the strip from each reel to the rolls.

3. In a rolling-mill for the manufacture of hot-rolled thin metal strips, the combination with reducing rolls, of a winding-reel adapted to receive the strip from the rolls, means for securing the strip to the reel, means for operating the reel and winding the strip thereon, and yielding means for exerting tension upon the strip between the rolls and the reel.

4. In a rolling-mill for the manufacture of hot-rolled thin metal strips, the combination with reducing rolls and mill tables arranged on opposite sides of said rolls, of a pair of winding-reels arranged one on each side of said rolls and above said tables, and chutes leading from said rolls to said reels, each of said chutes having a movable lower section.

5. In a rolling-mill for the manufacture of hot-rolled thin metal strips, the combination with reducing rolls, of a winding-reel adapted to receive the strip from the rolls, a guide for the strip adjacent to the reel, and means for moving the guide to and away from the reel.

6. In a rolling-mill for the manufacture of hot-rolled thin metal strips, the combination with reducing rolls, of a winding-reel adapted to receive the strip from the rolls, means for securing the strip to the reel, means for operating the reel and winding the strip thereon, and means for exerting tension upon the strip between the rolls and the reel, said tension-exerting means comprising a pair of spaced shiftable rollers adapted to bear one upon each face of the strip and fluid-pressure means for shifting said rollers.

7. In a rolling-mill for the manufacture of hot-rolled thin metal strips, the combination with reducing rolls, of a winding reel having an orifice adapted to receive the advance end of a strip delivered from the rolls, a movable locking-member adapted to lock the strip against the wall of the orifice, means for operating the locking-member, and means for operating the reel and winding the strip thereon.

8. In a rolling-mill for the manufacture of hot-rolled thin metal strips, the combination with reducing rolls, of a winding-reel adapted to receive the strip from the rolls, means for securing the strip to the reel, a motor detachably connected to the reel for rotating the reel and causing it to wind up the strip, means for disconnecting the motor, means for returning the strip to the rolls and thereby causing reverse rotation of the reel, and means for automatically stopping such reverse rotation at a predetermined point.

9. In a rolling-mill for the manufacture of hot-rolled thin metal strips, the combination with reducing rolls, of a winding-reel having a strip-receiving orifice adapted to receive the strip from the rolls and means for securing the strip to the reel, a guide for the strip adjacent to the reel, a motor detachably connected to the reel for rotating the reel and causing it to wind up the strip, means for disconnecting the motor, means for returning the strip to the rolls and thereby causing reverse rotation of the reel, means for stopping such reverse rotation, and a second motor for moving the reel to strip-receiving position with said orifice in alignment with said guide.

10. In a rolling mill for the manufacture of hot rolled thin metal strips, the combination with reducing rolls and mill tables arranged on opposite sides of said rolls, of a pair of winding reels arranged one on each side of said rolls and above said tables, and chutes leading from said rolls to said reels, said chutes being movable at least in part so as to lie clear of material on said mill tables.

11. In combination with a mill, a mill table on either side of the mill arranged to support material while the same is rolled back and

forth through the mill, means for effecting coiling of the material on either side of the mill as it issues therefrom, and pinch rolls for engaging the issuing material prior to the coiling thereof, the pinch rolls being so arranged as to be out of the way of material rolled back and forth on the mill tables.

12. In the method of rolling in a mill, the steps consisting in supplying a generally flat piece of material, rolling the same back and forth in the mill while it is in substantially flat form, continuing the rolling back and forth in the same mill and alternately coiling and uncoiling the rolled material.

13. In the method of rolling strip material in a mill, the steps consisting in rolling material back and forth while in substantially flat condition, and, after it has reached a desired thinness, rolling it back and forth in the same mill to effect a further reduction and coiling the same after each pass.

14. In the method of rolling in a mill, the steps consisting in rolling the material back and forth, engaging the surfaces of the issuing material after each pass so as to feed the same forward and exert a tension thereon, coiling the material beyond the point of engagement by the pinch rolls, and uncoiling and feeding it back through the pinch rolls to the mill.

15. In the method of rolling in a mill, the steps consisting in rolling material back and forth in substantially the flat state, and thereafter continuing the rolling by successive passes in said mill but diverting the material from its path and effecting coiling of the same.

16. In combination with a mill, a table on either side of the mill of such character as to support a flat piece of material from the time of issuance thereof from between the rolls of the mill until it has been fed back through the mill, the tables being effective for supporting the material while it is relatively thick and in an uncoiled state, and coilers adapted for automatically reeling and paying out material rolled on the mill when the same has been thinned and elongated.

17. In combination with a mill, a table on either side of the mill of such character as to support a flat piece of material from the time of issuance thereof from between the rolls of the mill until it has been fed back through the mill, the tables being effective for supporting the material while it is relatively thick and in an uncoiled state, coilers adapted for automatically reeling and paying out material rolled on the mill when the same has been thinned and elongated, and means for maintaining the coiled material at elevated temperature.

18. In combination with a mill for rolling material first in one direction and then in the other, a roll table on either side of the mill whereby a piece in flat or slab-like condition may be rolled back and forth and supported substantially in its entirety on the tables during such rolling, and coilers adapted for automatically reeling and paying out material rolled on the mill after the same has been thinned and elongated.

19. In combination with a mill for rolling material first in one direction and then in the other, a roll table on either side of the mill whereby a piece in flat or slab-like condition may be rolled back and forth and supported substantially in its entirety on the tables during such rolling, coilers adapted for automatically reeling and paying out material rolled on the mill after the same has been thinned and elongated, and means for guiding the material to the coilers.

20. In combination with a mill for rolling material first in one direction and then in the other, a mill table on either side of the mill arranged to support material in a flat condition while the same is rolled back and forth through the mill, means for effecting coiling of material on either side of the mill as it issues therefrom, and means for diverting material from the plane of a mill table into a path to be engaged by the coiler.

21. In combination with a mill for rolling material first in one direction and then in the other, a mill table on either side of the mill arranged to support material in a flat condition while the same is rolled back and forth through the mill, means for effecting coiling of material on either side of the mill as it issues therefrom, pinch rolls for engaging the issuing material prior to the coiling thereof, and means for diverting material from the plane of a mill table into a path to be engaged by the coiler.

22. In combination with a rolling mill, a mill table on either side of the mill arranged to support material while the same is rolled back and forth through the mill in the flat state, means for deflecting material upwardly from the plane of the tables, and a coiler on either side of the mill for engaging and coiling the deflected material.

23. In combination with a rolling mill, a mill table on either side of the mill arranged to support material while the same is rolled back and forth through the mill in the flat state, means for deflecting material upwardly from the plane of the tables, a coiler on either side of the mill for engaging and coiling the deflected material, and chambers above the plane of the tables containing the coilers, the chambers being arranged to prevent loss of heat of the coiled material.

24. In a method of rolling strip in a mill adapted to roll material first in one direction and then in the other and having pinch rolls on the opposite sides thereof, the steps including reducing the strip in the mill and passing it through the pinch rolls on the exit side of the mill and coiling the material be-

yond said pinch rolls, continuing the rolling until the trailing end of the strip passes through the mill rolls, stopping the material, and utilizing said pinch rolls to feed the material back to the mill.

25. In a method of rolling strip in a mill adapted to roll material first in one direction and then in the other and having pinch rolls on opposite sides thereof, the steps including driving the pinch rolls on the entering side of the mill to feed the leading end of a strip toward and through the mill and through the pinch rolls on the exit side, coiling the material beyond the last-mentioned pinch rolls, continuing the rolling until the trailing end of the strip passes through the mill rolls, and reversing the last-mentioned pinch rolls to feed the strip back toward and through the mill.

26. In a method of rolling strip in a mill adapted to roll material first in one direction and then in the other, and having pinch rolls on opposite sides thereof, the steps including reducing the strip in the mill, passing the leading end of the strip through the pinch rolls on the exit side thereof and coiling the material beyond said pinch rolls, continuing the rolling until the trailing end of the strip passes through the mill rolls, stopping the material before the trailing end has passed through the pinch rolls, and utilizing the pinch rolls for feeding such end of the strip back to the mill.

ROBERT M. KEENEY.
JOHN F. FERM.

Oct. 16, 1934. A. P. STECKEL 1,977,214

METHOD AND APPARATUS FOR HOT ROLLING STRIP METAL

Filed May 4, 1931 7 Sheets-Sheet 1

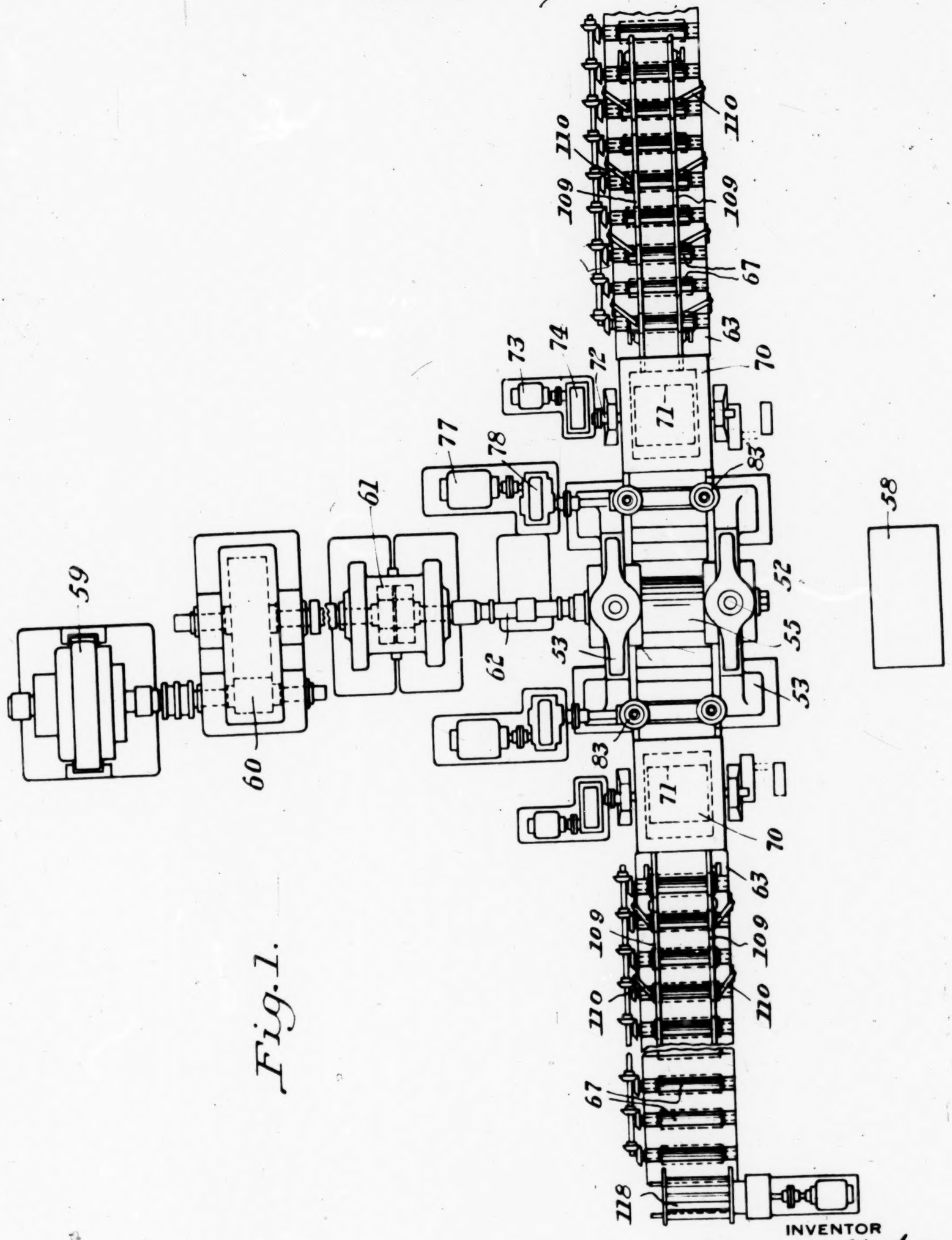


Fig. 1.

INVENTOR
Abram P Steckel
by his attorneys
Byrnes, Stebbins, Parmelee & Blenko

Oct. 16, 1934. A. F. STECKEL 1,977,214

METHOD AND APPARATUS FOR HOT ROLLING STRIP METAL

Filed May 4, 1931 7 Sheets-Sheet 2

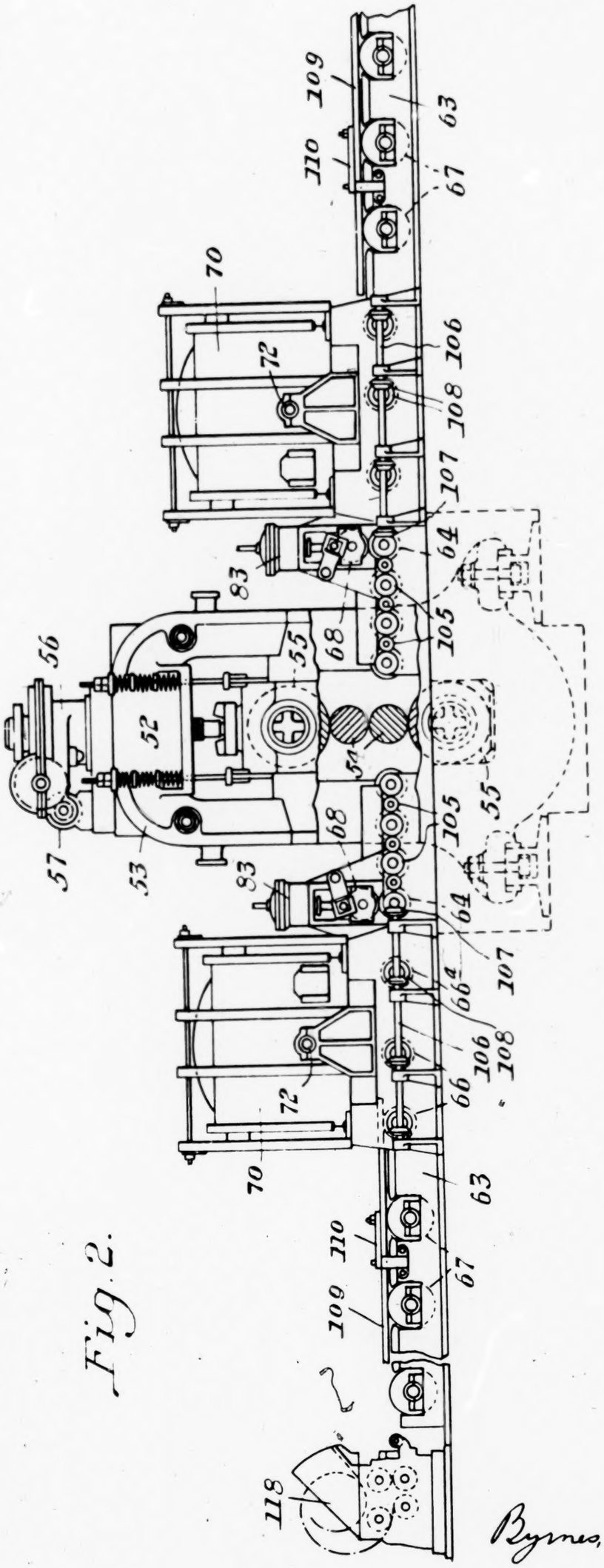


Fig. 2.

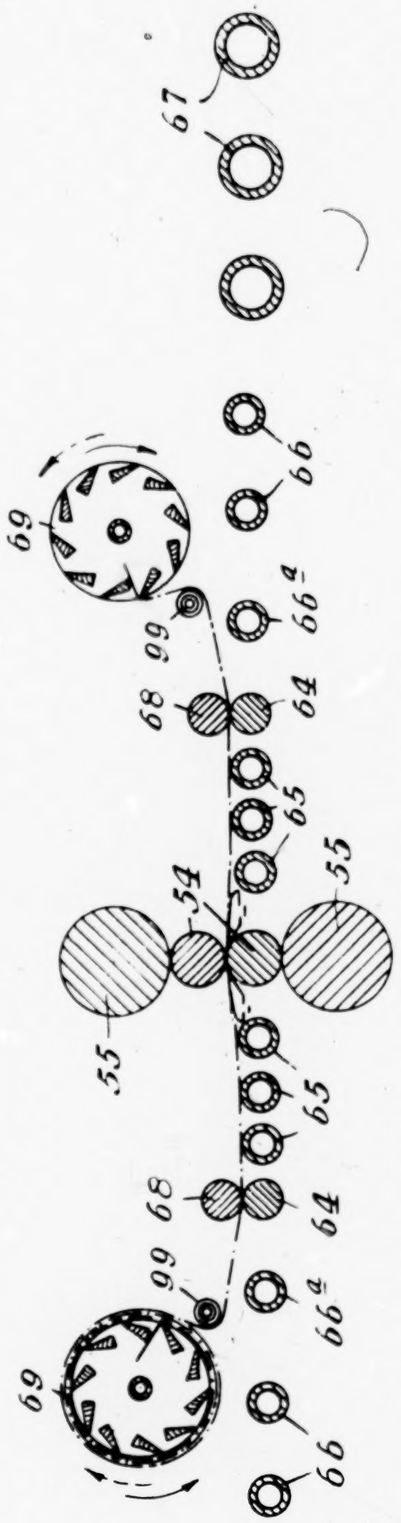


Fig. 3.

INVENTOR
Abram F. Steckel
by his attorneys
Byrnes, Stebbins, Parmelee & Blenko

Oct. 16, 1934. A. P. STECKEL 1,977,214

METHOD AND APPARATUS FOR HOT ROLLING STRIP METAL

Filed May 4, 1931 7 Sheets-Sheet 3

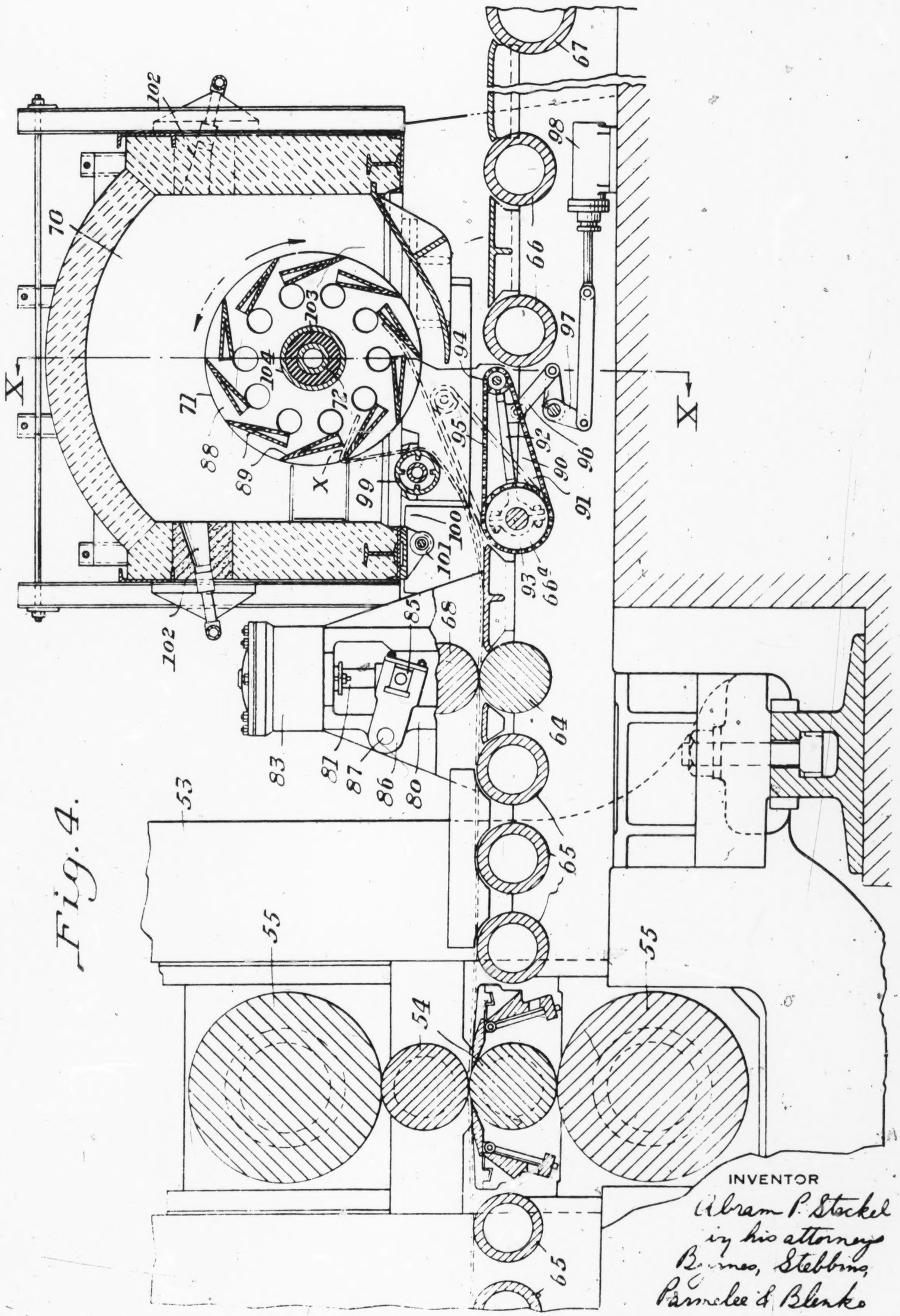


Fig. 4.

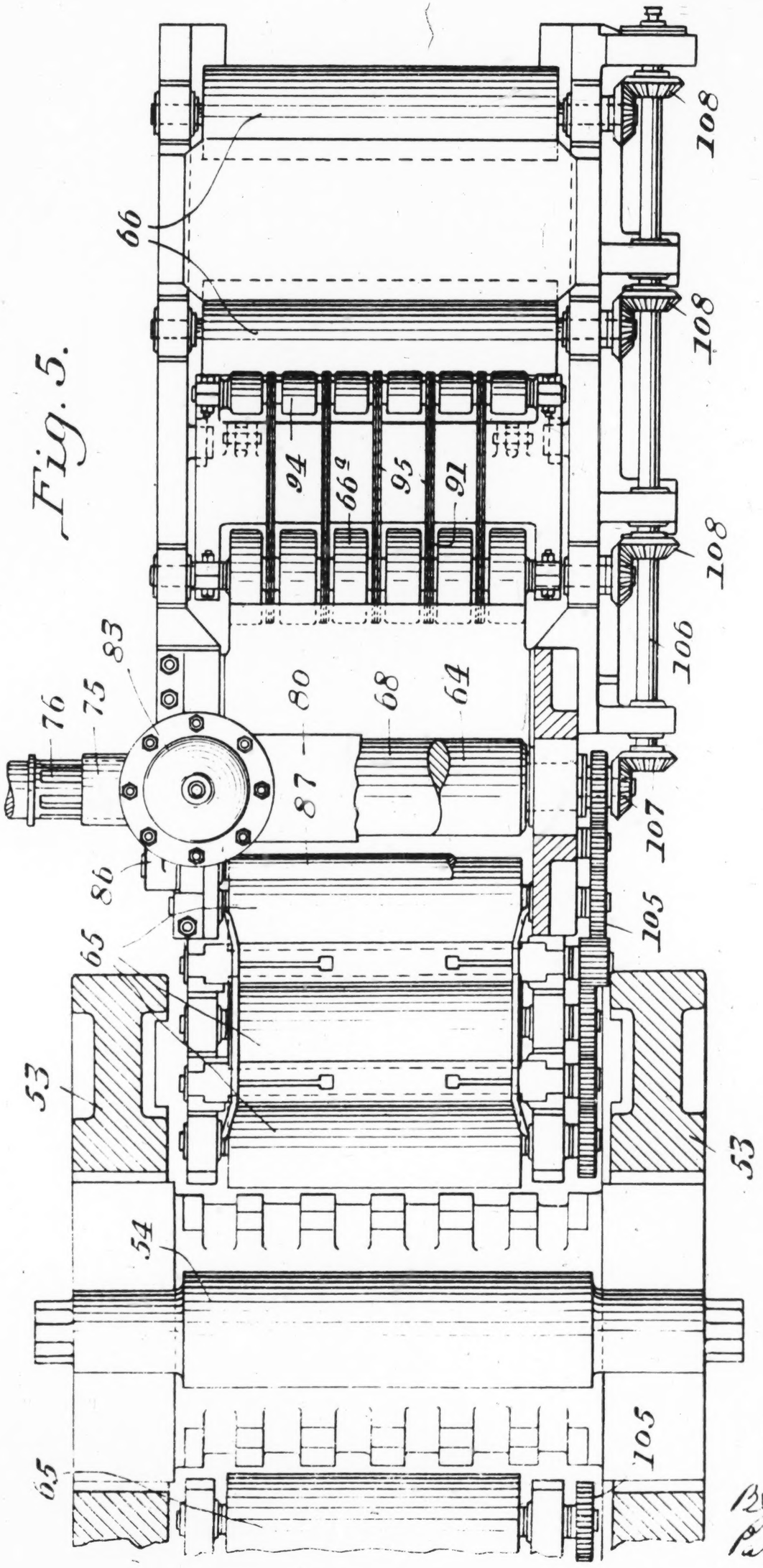
INVENTOR
Abram P. Steckel
by his attorneys
Barnes, Stebbins,
Parmelee & Blenko

Oct. 16, 1934. A. P. STECKEL 1,977,214

METHOD AND APPARATUS FOR HOT ROLLING STRIP METAL

Filed May 4, 1931 7 Sheets-Sheet 4

Fig. 5.



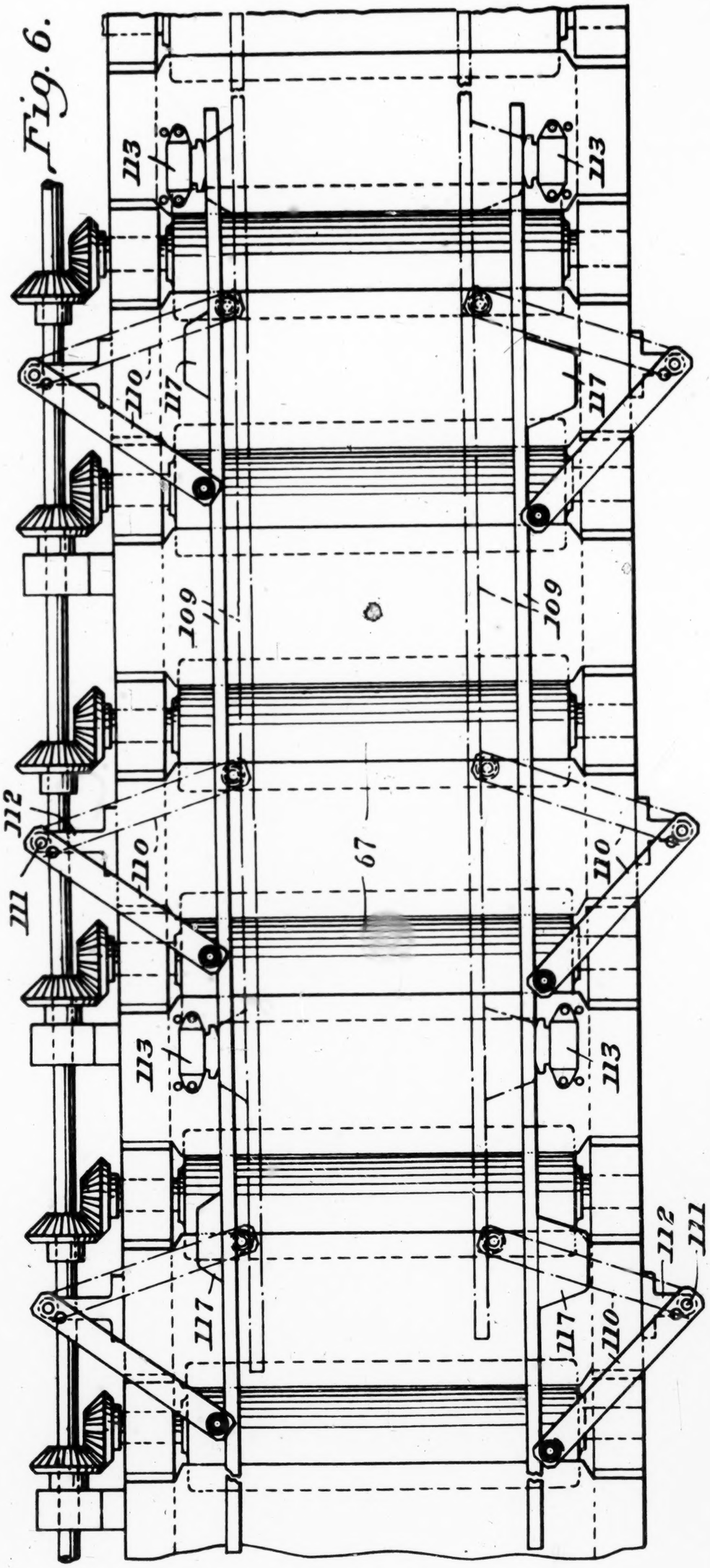
INVENTOR
Abram P. Steckel
by his attorneys
Byrnes, Stebbins,
Parmelee & Bienko

Oct. 16, 1934. A. P. STECKEL 1,977,214

METHOD AND APPARATUS FOR HOT ROLLING STRIP METAL

Filed May 4, 1931 7 Sheets-Sheet 5

Fig. 6.



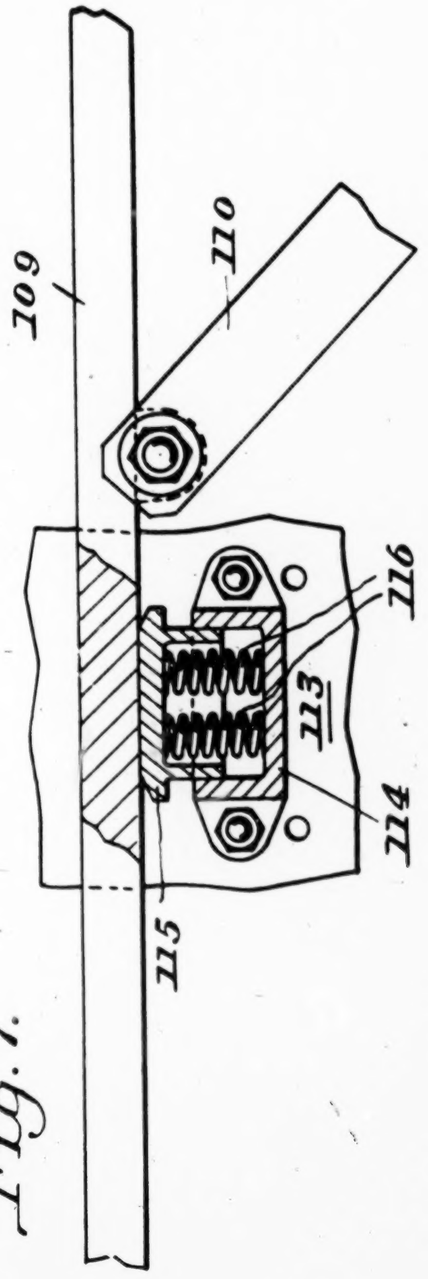


Fig. 7.

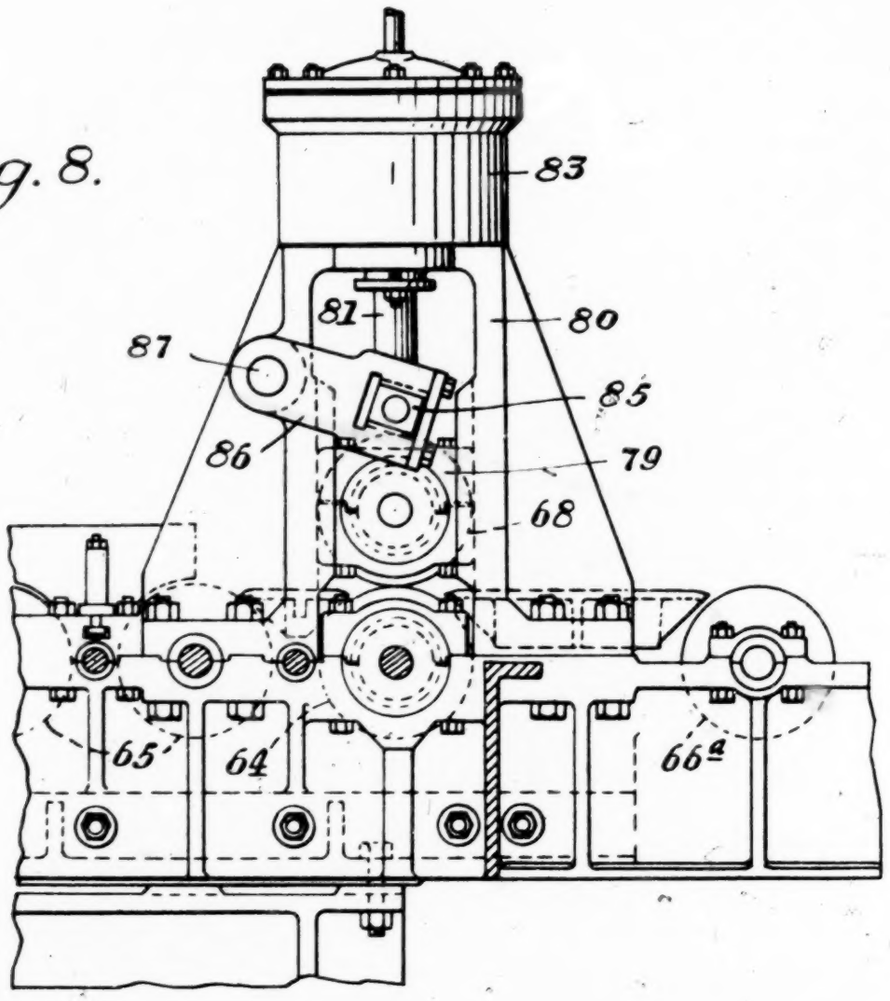
INVENTOR
Abram P. Steckel
by his attorneys
Byrnes, Stebbins,
Parmelee & Blenko

Oct. 16, 1934. A. P. STECKEL 1,977,214

METHOD AND APPARATUS FOR HOT ROLLING STRIP METAL

Filed May 4, 1931 7 Sheets-Sheet 6

Fig. 8.



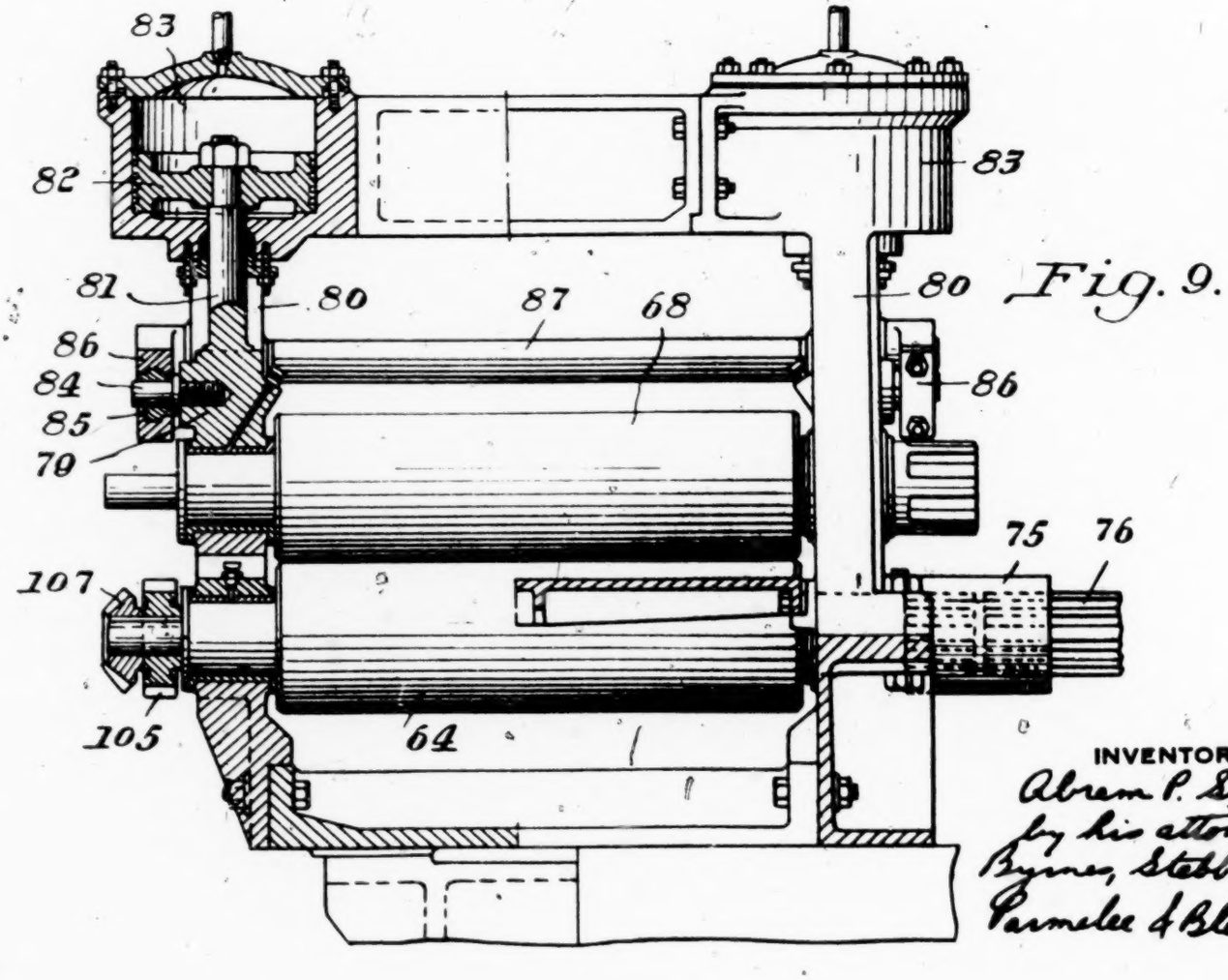


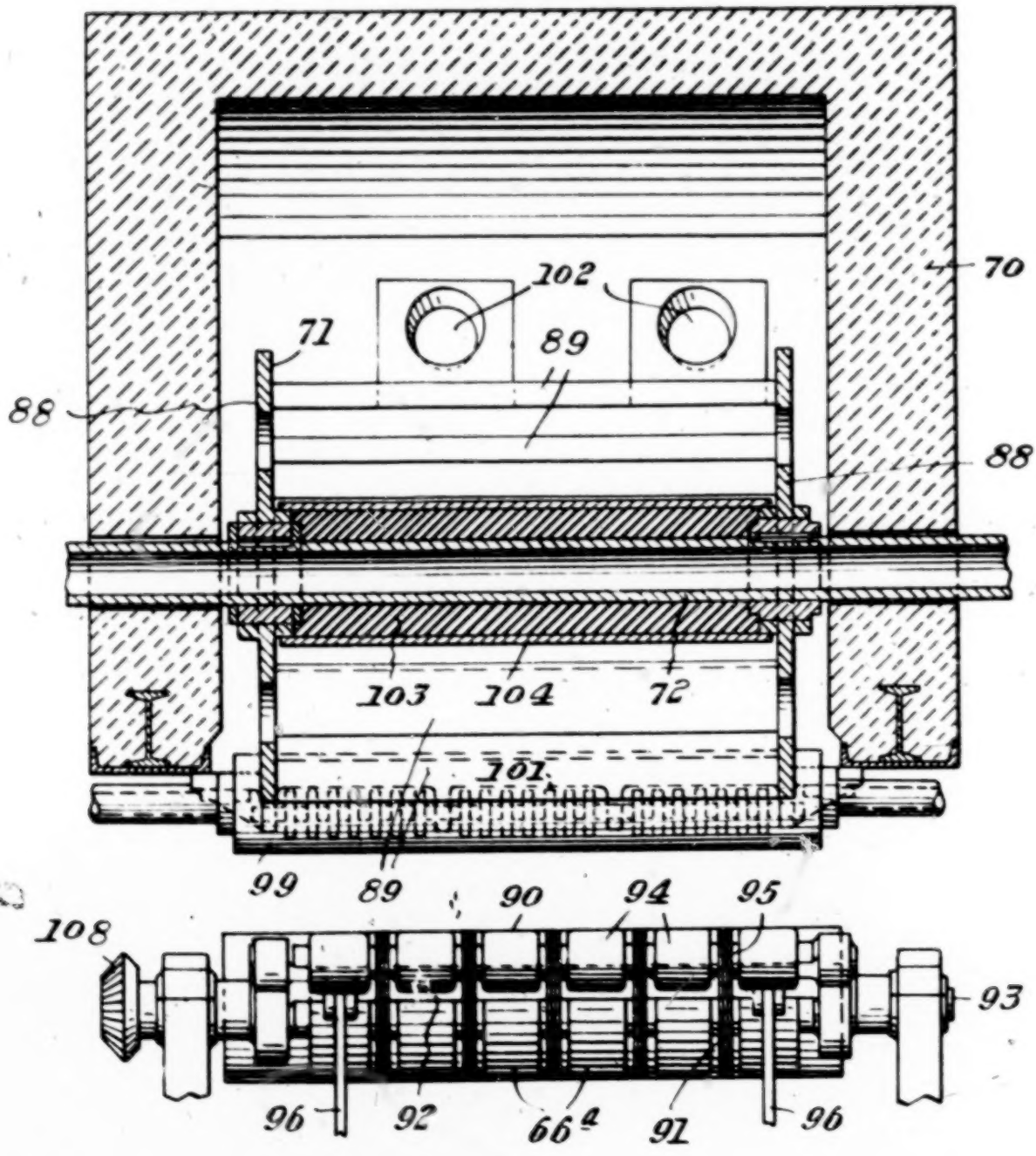
Fig. 9.

INVENTOR
Abram P. Steckel
by his attorneys
Byrnes, Stebbins,
Parmelee & Blanke

METHOD AND APPARATUS FOR HOT ROLLING STRIP METAL

Filed May 4, 1931 7 Sheets-Sheet 7

Fig. 10.



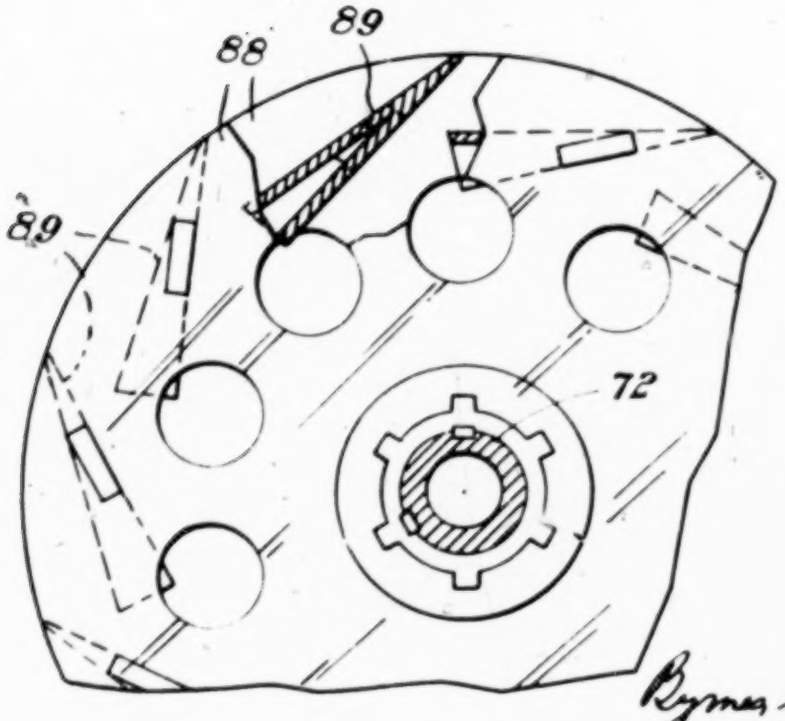


Fig. 11.

INVENTOR
Abram P. Steckel
by his attorneys
Byrnes, Stebbins, Parmelee & Blenko

Patented Oct. 16, 1934 1,977,214

UNITED STATES PATENT OFFICE

1,977,214

METHOD AND APPARATUS FOR HOT ROLLING STRIP METAL

Abram P. Steckel, Youngstown, Ohio, assignor to The Cold Metal Process Company, Youngstown, Ohio, a corporation of Ohio

Application May 4, 1931, Serial No. 535,029

22 Claims. (Cl. 80—2)

This invention relates to the hot rolling of strip metal, the word "strip" being used as a word of general definition, and not of limitation to those classifications of flat metal of indefinite length generally designated for commercial purposes as strip.

The accepted method of rolling strip today is to supply a heated slab to a mill train comprising a large number of stands, say ten, in alinement, the heated slab being elongated and reduced in the successive passes. The early stands operate as tandem mills, that is to say the piece is in engagement with only one stand at a time, but the later stands are generally operated as a continuous mill, that is to say the piece is in process of rolling in several passes at one time. Mills of this character require a very high capital investment and the production is relatively limited. The rate of production is limited by the capacity of the last stand. It is this stand which is operated at the highest speed, the preceding mills being run at successively lower speeds because of the fact that the piece being reduced is relatively shorter. Most of the stands in a continuous mill of this sort therefore are operating at speeds far below the possible maximum, whereas in the type of mill herein disclosed the mill may be operated on each pass at maximum speed or at speeds approaching maximum. As a consequence, it is possible, for a given capacity, to install a mill of my improved type at about one-fourth the cost of a mill of the continuous type.

Such mills also require a very large amount of floor space since all of the rolling is done while the piece is in the flat. Despite the fact that the later stands in the train are operated in a continuous manner, there must still be a reasonable spacing between the mills so as to give access to the stands and to provide for forming a buckle in the piece to accommodate minor discrepancies in the speed of revolution of successive stands which simultaneously engage the piece. There must also be a run-out table beyond the last stand, which run-out table is long enough to accommodate the product. In continuous mills for narrow strip it is common practice to turn the strip on edge and to lap it back and forth over a relatively short cooling bed, but this is not possible with wide strip. The size of such an installation may be appreciated when it is considered that a representative mill of this type having ten stands requires motors whose horse power totals 30,000 and requires a building length in excess of 800 ft. In my improved mill only about one-fifth the motor capacity is required. Yet with this relatively small capacity, approximately half as much tonnage may be produced at one-eighth the total investment.

I provide a mill which is relatively simple and compact in construction, employing preferably but a single reducing stand, although it may in certain instances be desirable to divide the work between two stands. I am able to make each pass at a speed which is determined only by the power supply of the mill and which is not limited by the requirements of a succeeding stand. I prefer to employ a four-high mill of the reversing type, although other types of mills such as a three-high mill wherein the work is fed alternately over and under the middle roll, may be employed.

Each pass will ordinarily be followed by a succeeding pass as rapidly as possible, thereby utilizing practically all of the operating time of the mill.

It is of course well known to reduce the thickness of slabs by rolling them back and forth through a mill stand, but the extent of the reduction has always been relatively limited by two factors, namely, the elongation of the material to a point where it cannot be satisfactorily handled, and the loss of heat to a point where rolling can no longer be profitably continued.

I overcome these difficulties by initially hot rolling a piece of metal in the flat so as to reduce it in thickness sufficiently to permit of coiling it, and in the same heat feeding it from the coil and further reducing it. I preferably employ coilers on each side of the mill and after the initial flat rolling the material is coiled and uncoiled on each pass, the material being fed from a coil to the mill and being coiled up on the other side as it issues.

Mills of the continuous type are designed taking into consideration the rapid loss of heat occasioned by the exposure of the entire surface to the cooling action of the atmosphere. By reason of the fact that as the piece becomes thinner a relatively greater area per unit of volume is exposed for cooling, there is a rapid loss of heat. If, however, this material is coiled, the exposed area is only a very small fraction of the total area of the piece. Furthermore, the coiling permits of using relatively short mill tables, thus saving space and mill cost. The coilers are preferably arranged in heat conserving chambers so as to still further reduce the heat loss and to minimize scaling.

There is a great advantage from the standpoint of heating in initially supplying the hot metal to the mill in slab form. It is practically impossible to uniformly heat a large coil of material to rolling temperature since the edges will always be too hot and the metal of the coil will not be of uniform temperature either from end to end or side to side. With a slab, however, it is relatively easy in existing furnaces to obtain uniformity of heating with a minimum of scale loss.

In order to operate at high speed, it is necessary to have some positive means for feeding the end of the coiled strip back to the mill. For this purpose I prefer to employ pinch rolls on either side of the stand. In practice, the operator will run the mill so as to feed the material in one direction and continue the rolling until the trailing end is out of the grip of the reducing rolls. However, he will bring the mill to a stop before the piece is freed of the pinch rolls. By driving the pinch rolls in a reverse direction, he is enabled to feed the material back to the mill.

The pinch rolls operate to maintain the material under tension and this is highly desirable. It insures straightness of the product and materially simplifies the handling. The pinch rolls on the exit side will be arranged to exert a forward pull on the material, and those on the entering side will be arranged to impart a drag thereto. This causes the material to issue straight. If there are any slight irregularities due to over-rolling at one point or another across the width of the strip, such irregularities will be largely or entirely removed.

During the early stages of the rolling mill when the material is in slab form it is sufficiently stiff even at rolling temperature that it may be thrust forward by the rolls or by the pinch rolls very rapidly. When it is quite thin there is a tendency of the material to buckle as it issues from the mill or from the pinch rolls unless it is taken up by the reel as fast as it issues. The reel must be of such construction as to engage the material positively and without delay. I employ a form of reel which serves this purpose and which also is effective in combination with other apparatus employed for breaking or loosening the scale between passes, thus insuring that no scale will be rolled into the surface of the strip, reducing its quality. This form of reeling mechanism, however, operates most satisfactorily only after the material is relatively thin. There is an intermediate stage of reduction between the flat rolling of the thick slab and the reeling of the thin material which, for purposes of heat saving, and economy of installation by reason of shortening of the tables, is best carried out by reeling the material. I employ the same reels for this material of intermediate thickness but operate them in the opposite direction, as hereinafter explained.

There are certain difficulties attendant upon rolling the material in the flat at the high speeds I contemplate, which difficulties must be overcome to make the installation desirable. As the material is reduced in thickness, it widens. In the early stages of rolling, where the slab is still relatively short, it is not so important that it be fed exactly squarely into the rolls, but as it increases in length its alinement becomes more and more important. In order to obtain such alinement, side guides must be employed, which side guides necessarily are spaced for entering the piece a distance only slightly more than the width of the piece being entered. On the exit side of the mill, however, the guides should have a relatively wider spacing in order to prevent cobbling. I provide automatically operable guides which fulfill these requirements.

In the accompanying drawings, illustrating a present preferred embodiment of my invention,

Figure 1 is a top plan view of the mill;

Figure 2 is a side elevation to an enlarged scale of a portion thereof;

Figure 3 is a diagrammatic view illustrating the operation of the mill;

Figure 4 is a vertical longitudinal section through the mill stand and one of the coilers;

Figure 5 is a top plan view, partly broken away, of that portion of the installation illustrated in Figure 4;

Figure 6 is a top plan view of a portion of one of the tables showing the guides;

Figure 7 is a detail view, partly broken away, showing a stop for the guides;

Figure 8 is a side elevation of the pinch roll structure;

Figure 9 is an elevation at right angles to the elevation of Figure 8, and partly broken away;

Figure 10 is a transverse section taken on the line X—X of Figure 4, certain parts being omitted for sake of clearness; and

Figure 11 is a side elevation, partly broken away, of one of the coiling reels.

Referring first to Figures 1 to 3 inclusive, there is shown a mill stand indicated generally by the reference character 52 and comprising housings 53 supporting work rolls 54 and backing rolls 55. The backing rolls are preferably provided with anti-friction bearings as described and claimed in my U. S. Patent No. 1,779,195. The mill is provided with screw downs indicated generally by the reference character 56, which screw downs are actuated by an electric motor 57 controlled from the operator's pulpit 58 so that the setting of the mill may be rapidly adjusted. The work rolls 54 are driven by a motor 59 through reducing gears 60, pinions 61 and spindles 62.

A mill table indicated generally by the reference character 63 is provided at each side of the stand 52. A roll 64 spaced a short distance from the work rolls is provided on each side of the mill. Relatively closely spaced table rollers 65 lie between the stand and the rolls 64, and more widely spaced rollers 66 and 67 lie therebeyond. The rolls 64 cooperate with rolls 68 to form a pinch roll unit effective for engaging material. The rolls 68 are arranged to be raised or lowered as desired. At the beginning of a rolling a hot slab is supplied to one of the tables 63 and is fed to the mill which reduces and elongates it, delivering it to the roll table 63 on the opposite side. The mill is then reversed and the operation is repeated. This continues until the slab is thinned sufficiently to permit of coiling it. When this stage of reduction is reached, the material is deflected upwardly from the plane of the tables 63 to coilers. The coilers are indicated generally at 69 in the drawings and are contained in heated chambers 70 lying above the tables 63. The coilers comprise reels 71 mounted on shafts 72 driven by motors 73 through gears 74.

The pinch roll structure is best illustrated in Figures 4, 8 and 9. The rolls 64 are driven through coupling boxes 75 and spindles 76 from motors 77 (see Fig. 1) through reducing gears 78. The motors 77 are controlled from the operator's pulpit 58 as are the motors 73 and 59.

The rolls 68 are mounted in bearings 79 slidable

in housings 80. A piston rod 81 extends upwardly from each bearing 79 to a piston 82 in a cylinder 83 formed in the upper part of the housing 80. The pistons 82 may be raised or lowered by controlling the supply of air to the cylinders 83. The movement of the cylinders is also controlled from the operator's pulpit 58. In order to insure simultaneous raising and lowering of the bearing 79 for each end of a roll 68, the bearings are interconnected. Each bearing carries a stud 84 extending through a block 85 slidable in the forked end of a lever 86. The levers 86 are keyed to a rocked shaft 87 so that the bearings 79 are bound to move up or down together.

The coiling mechanism is best illustrated in Figures 4, 5, 10 and 11. Each reel 71 comprises spaced disks 88 with V-shaped bars 89 extending therebetween to form a squirrel cage. The reels may be driven in either direction as desired.

A kick-up indicated generally by the reference character 90 is provided in each table 63 for deflecting material upwardly to the coiler. Each kick-up comprises a driven table roller 66*a* having circumferential grooves with sprocket teeth 91 therein. A frame 92 is pivoted on the shaft 93 of the roller 66*a* and carries a roller 94 having toothed circumferential grooves corresponding to those of the roller 66*a*. Sprocket chains 95 extend around these teeth, the upper flight of the chains lying in the plane of the table when the frame 92 is in its lowered position. The frame 92 is connected by a link 96 to a bell crank 97 which is actuated by a fluid cylinder 98. The cylinder is controlled from the operator's pulpit 58.

When it is desired to coil a strip of material fluid pressure is supplied to the cylinder 98, causing the bell crank 97 to be rotated in a counterclockwise direction, as viewed in Figure 4, and tilting the frame 92 upwardly about the shaft 93. This moves the kick-up to the dot and dash line position of Figure 4 and guides the leading end of the oncoming material into the chamber 70. It is preferred that the reeling be commenced when the material is relatively thick, say ¾ of an inch. For handling material of such thickness the reel 69 is driven in the direction indicated in Figure 4 by the arrow shown in dotted lines. The leading end of the relatively thick and stiff strip passes between adjacent bars of the squirrel cage 71. The peripheral speed of the reel approximates the entering speed of the material and the reel gathers such material as it is fed forward by the pinch rolls. After the reeling in one direction is completed, the direction of rotation of the pinch rolls, the mill and the reel is reversed and the piece is fed back for another pass.

After the material gets sufficiently thin (say about ½ inch) that it becomes practical to bend it sharply, it is desirable to impart such sharp bending so as to loosen the scale and permit it to fall off. Therefore, when the material reaches this thinness, the receiving reel is driven in the direction indicated by the solid arrow. The entering end of the steel being rolled passes between adjacent bars of the squirrel cage 71 and the rotation of the squirrel cage causes the strip to be doubled over the edge of one of the bars 89, as indicated at X in Figure 4. The material thereafter travels around a scale breaking roll 99.

When the material reaches this thinness the question of scale formation becomes important. If scale is not removed between passes it is rolled into the strip and also injures the face of the work rolls in the mill. The formation of a small amount of scale after the rolling has been completed is relatively unimportant, but the continued passing of scaly material through the rolls must be overcome. The flexing of the material around the roll 99 breaks the scale and it is dropped or thrown off prior to the next rolling, thus giving a cleaner product and insuring long life for the work rolls. I term the first mentioned type of coiling "tangential coiling" and the other type as "reverse coiling".

It is intended that the operator will stop the movement of the material just after its trailing end leaves the work rolls 54 and before it passes out from the grip of the pinch rolls 64 and 68, but in the event that he does not check the movement in time and the entire strip is wound on the coiler, the outer end may be readily engaged through a space 100 and fed back to the pinch rolls by tongs. A guide roll 101 protects the surface of the material during such procedure.

The chambers 70 are made of refractory material and will be kept up to a desired temperature in operation by means of fuel burners 102. Relatively only a small amount of heat will be required as the material may be rolled so rapidly in the mill and with such frequency that enough rolling energy is transformed into heat to very materially retard cooling. This is particularly so because of the fact that only a relatively small portion of the length is exposed to atmospheric cooling from the time it issues from the rolls until it is in the coiler.

The shaft 72 of the reel is provided with insulation 103 and a protecting sleeve 104. The shaft 72 being hollow, it is readily maintained at sufficiently low temperature to insure adequate strength. Air cooling alone may be sufficient, but I prefer to let a small quantity of water trickle through. Because of the insulation 103 there is no danger of loss of heat or of chilling the interior wraps of the coil of metal.

It is found in practice that the doubling back of the material over the bars 89 to obtain initial engagement of the reel with the strip is not detrimental to the quality of the material as the bend is not through an unduly large angle, and the metal thereat is kept at elevated temperature and the bend rolled out in the mill.

The construction of the roll tables 63 and the side guides is best shown in Figures 1, 2 and 5 to 7 inclusive. The table rollers adjacent the mill are driven by the motor 73. The roll 64 forming the bottom pinch roll is connected through a spur gear train 105 to the rollers 65. The roll 64 also drives a shaft 106 through miter gears 107. This shaft extends along the table 63 and, through miter gears 108, drives the table rollers 66 and 66*a*. The rollers 67 are driven in a like fashion and may be operated from a separate motor. This will usually be desirable because such rollers will be idle during the entire portion of the operation when the metal is being coiled between passes.

The side guides comprise metal bars 109 connected to parallel links 110 pivoted at 111 on brackets 112 secured to the sides of the table. The bars 109 rest on the table rollers 67. The table shown in detail in Figure 6 lies at the left hand side of the mill as viewed in Figures 1 and 2, and the solid line position of the guides is their open position which is desired when receiving material. Assume now that a slab of metal to be rolled is lying on such table and it is desired to feed the same to the mill. The rolls 67 are rotated in such direction as to carry the metal to the right. By reason of the frictional engagement of the side guides 109 with the rollers, such

guides are also carried to the right, swinging on the links 110. By reason of such movement they assume the position shown by dot and dash lines, and it will be noted that the guides in this position are much closer together and are effective for accurately alining the entering material. The further movement of the guides is limited by stops 113, which stops consist of casings 114 bolted to the mill table and carrying buffers 115 backed by coil springs 116.

When the rollers 67 are driven in the reverse direction the side guides are urged to the left as viewed in Figure 6 and swing back to the solid line position, their movement in this direction being limited by the side guides proper coming into engagement with the stops 113. The side guides are provided with pads 117 which engage the stops when the guides are at their inner position. The links 110 are provided with an extra hole or holes at their outer end through which they may be pivoted at 111 so as to vary their effective length and hence the spacing of the guides. The table is provided with a corresponding series of holes as shown in Figure 7, so that the stops 113 may be adjusted to correspond.

It will be noted that the initial angularity of the links on one side of the table differs from the initial angularity of the links on the other side of the table. The reason for this is that as the links move from the solid line to the dot and dash line position they move inwardly so long as the links are traveling toward a position of perpendicularity with respect to the axis of the table, and then slightly outwardly as the links move from such perpendicular position to their position of rest. If the initial angularity of the links on the two sides of the table were the same, such links might reach a condition of perpendicularity at the same moment, thus possibly bringing the guides so closely together as to interfere with the travel of the piece. However, this does not occur with the construction shown. On the contrary, the side guide shown at the upper portion of Figure 6 reaches its innermost position somewhat ahead of the guide on the opposite side. In so doing it engages the edge of the material and alines it. Then in coming to its position of rest it moves away from the material a slight distance so as to give it utter freedom of movement toward the mill, while limiting its sidewise movement to the slight clearance afforded by the travel of the links beyond their position of perpendicularity. The side guide shown at the lower portion of Figure 6 also engages the edge of the strip if the same is mis-alined, and thereby straightens it up for its travel into the mill.

In operation a heated slab of material will be supplied to one of the tables 63 and run back and forth through the mill, the screw down being operated so as to bring the rolls successively closer together, thus thinning and elongating the piece. These passes will be very rapid and with the least possible loss of time, thus getting the strip down to a thinness suitable for coiling without serious loss of heat. When the material is thin enough to coil, the kick-ups will be actuated to feed the issuing strip to one of the coilers. The rolling will then be continued, feeding from one coil to another, the pinch rolls serving to feed the material. After the rolling has been completed the material will be permitted after the last pass to travel to the end of the left hand table 63 and to a centerless coiler 118 of usual construction, from which it may be taken away.

I have illustrated and described a present preferred embodiment of the invention. It will be understood, however, that this is by way of illustration only, and that it may be otherwise embodied or practiced within the scope of the following claims.

I claim:

1. In combination with a rolling mill adapted for the rolling of material first in one direction and then in the other, a roll table, a coiler above the table, and means for diverting material from the roll table upwardly into the coiler, the coiler having a portion rotated in such direction that when it engages the leading end of the material being rolled it has a component of motion in a direction opposite to the movement of such leading end, and a guide roll associated with the coiler around which the material passes, the guide roll being spaced above the table a distance sufficient to permit of travel of the material over the table when such material is being rolled and maintained in the flat condition.

2. In combination with a mill, a mill table on either side of the mill arranged to support material while the same is rolled back and forth through the mill, means for effecting coiling of the material on either side of the mill as it issues therefrom, and pinch rolls for engaging the issuing material prior to the coiling thereof, the pinch rolls being in the plane of the table but so arranged as to be out of the way of material rolled back and forth on the mill tables.

3. In combination with a mill, pinch rolls on either side of the mill for tensioning issuing material, means beyond the pinch rolls for effecting coiling of the material, and means for retaining the heat of the coiled material.

4. In combination with a mill, a table on either side of the mill of such character as to support a flat piece of material from the time of issuance thereof from between the rolls of the mill until it has been fed back through the mill, the tables being effective for supporting the material while it is relatively thick and in an uncoiled state, and coilers adapted for automatically reeling and paying out material rolled on the mill when the same has been thinned and elongated, sections of the table being movable to divert material from the tables to the coilers.

5. In combination with a rolling mill, a mill table on either side of the mill arranged to support material while the same is rolled back and forth through the mill in the flat state, means comprising sections of the table for deflecting material upwardly from the plane of the tables, a coiler on either side of the mill for engaging and coiling the deflected material, and chambers above the plane of the tables containing the coilers, the chambers being arranged to prevent loss of heat of the coiled material.

6. In combination with a rolling mill, a table having rollers rotatable in either direction, a side guide movable on the rollers, and means for moving the side guide inwardly when the rollers rotate to move the guide in one direction and outwardly when they rotate to move it in the other direction.

7. In combination with a rolling mill, a table having means for moving material therealong, and a side guide resting on the material moving means and movable therewith, means engaging the side guide arranged to move it laterally on actuation of the material moving means.

8. In combination with a rolling mill, a table having means for moving material therealong, and a side guide movable laterally of the table

when the material moving means is actuated, there being a frictional driving connection between the material moving means and the guide.

9. In combination with a rolling mill, a table having material moving means, a side guide resting on the material moving means, laterally extending links connected to the side guides, and stop means for limiting movement of the side guides.

10. In combination with a rolling mill, a table having material moving means, side guides resting thereon, there being a side guide adjacent each side of the table, the side guides being movable with the material moving means, links connected to the side guides, and stop means for limiting the movement of the guides, the links for one side guide being at a different inclination than the links for the other side guide when the guides are at the end of their travel.

11. In the method of hot rolling, the steps consisting in subjecting hot material to successive reducing passes to thin and elongate it, coiling it between passes and flexing it between passes, and prior to coiling, sufficiently to effect removal of formed scale.

12. In the method of rolling, the steps consisting in hot rolling a flat piece of metal to reduce it sufficiently in thickness to permit of coiling it, thereafter subjecting it to repeated reducing passes, coiling it between passes, and removing scale from the material between passes.

13. In combination with a rolling mill, a coiler on each side of the mill for effecting coiling of the material, and means for flexing material between passes in the mill, and prior to coiling, sufficiently to effect removal of scale therefrom.

14. In the method of rolling, the steps consisting in subjecting material to successive reducing passes, feeding it to a coiler between passes, coiling it in one direction between certain of said passes, and coiling it in the other direction between other of said passes.

15. In the method of rolling, the steps consisting in subjecting material to successive reducing passes, coiling the material tangentially between passes, and, at a later stage in the operation, coiling it in the reverse direction between passes.

16. In the method of rolling, the steps consisting in subjecting material to successive reducing passes, coiling the material tangentially between passes, and, at a later stage in the operation, coiling it in the reverse direction between passes, and flexing the material through a relatively sharp bend during such reverse coiling so as to effect removal of scale.

17. In combination with a rolling mill adapted for the rolling of material first in one direction and then in the other, a roll table for feeding material to the mill, a pinch roll cooperating with a roll of the roll table, means for driving one of the cooperating pinch rolls, a second pinch roll cooperating with a roll of the table on the opposite side of the mill from the first-mentioned pinch roll, and means whereby said second-mentioned pinch roll exerts a restraining tension on said material.

18. In combination with a rolling mill adapted for the rolling of material first in one direction and then in the other, roll tables on each side of the mill and coilers above the roll tables, sections of the tables being movable upwardly to divert material to the coilers.

19. In combination with a rolling mill and a table therefor, a side guide positioned over the table and movable longitudinally thereof, and connections for the side guide effective for moving it laterally of the table upon longitudinal movement thereof.

20. In combination with a rolling mill and a table therefor, a side guide positioned over the table and movable longitudinally thereof, connections for the side guide effective for moving it laterally of the table upon longitudinal movement thereof, and stops for limiting such lateral movement, the stops being so positioned that the guide occupies one position laterally of the table upon longitudinal movement in one direction, and another position laterally of the table upon longitudinal movement in the other direction.

21. In combination with a rolling mill and a table therefor adapted to feed material to the mill or to receive the same therefrom, side guides lying over the table and movable longitudinally thereof, connections for the side guides effective for causing lateral movement thereof when the side guides are moved longitudinally of the table, and stops for limiting such lateral movement, the stops being so positioned as to leave the side guides relatively closely spaced for a feeding action and relatively more widely spaced for receiving material from the mill.

22. In combination with a mill for rolling material in either direction, roll tables on each side of the mill, reels arranged above the roll tables for coiling material issuing from the mill and for feeding coiled material back to the mill, heat conserving chambers surrounding the reels, the chambers lying above the roll tables and being open at the bottom, and kick-ups for diverting material from the roll tables through the bottoms of the chambers to the reels.

ABRAM P. STRCKEL.

Demonstrates New Principle Of Rolling Hot Strip

APPLICATION of the Steckel-type mill to the hot rolling of strip was demonstrated last week by officials of the Cold Metal Process Co. to a group of about 60 engineers including 14 from France, Belgium, Germany, England, Wales, Sweden, Czecho-Slovakia, Italy and the Saar. The mill, an experimental assembly, is located at the Brier Hill plate mill division of the Youngstown Sheet & Tube Co., Youngstown, O.

Only one stand of 4-high rolls is used, this being served by two elevated holding furnaces, one spanning the approach table and the other the runout table, as shown in the accompanying illustration. Mounted inside each furnace is a 48-inch diameter reel made of chrome-nickel heat-resisting steel. The purpose of the furnaces is merely to restore the initial heat of the slab so that as the partially-rolled piece emerges from the furnace and enters the rolls, the temperature will be uniform throughout its length.

During the demonstration slabs 4 inches thick, 9 feet long and weighing approximately 2500 pounds were used as the raw material. Each slab, heated to about 1600 degrees Fahr., is brought from the slab heating furnace by crane, deposited on the approach table leading to the mill, and then run through a scale breaker. While in transit through this unit the steel passes between two circular steel brushes which rotate at high speed and loosen the scale on both the top and bottom surfaces and, as the piece progresses, sprays of high-pressure water, directed against both surfaces, remove the loosened scale.

After the slab leaves the scale breaker it enters a set of pinch rolls, equipped with an air-operated hold-down and driven by a separate motor, which direct it into the 4-high mill equipped with 20-inch diameter work rolls and 36-inch backup rolls, all with 72-inch body. The steel is given 11 passes back and forth through the mill and, following each reduction, is conveyed beneath the holding furnace spanning the roller table, away from the mill.

Previous to the eleventh pass a set of dogs is canted on the roller table on the runout side and, as the front end of the piece emerges from the mill and finally the pinch rolls, it is directed at an upward angle by the dogs into the holding furnace and reeled into a coil while reduction of the remaining section continues. The holding furnace is gas fired and preserves the steel at 1600 degrees Fahr., the initial temperature of the slab.

Pinch Rolls Are Automatic

When the rear end of the piece emerges from the mill and is still in the grip of the pinch rolls at the exit side, the mill is reversed and the strip returns through the work rolls and pinch rolls and into the opposite holding furnace where it again is reeled and restored to a temperature of 1600 degrees. To prevent excessive tension on the piece in the process of reduction, only one set of pinch rolls functions, this always being on the rear side of the mill for the purpose of pulling the stock through the rolls and off the reel at the entrance side.

Reduction continues with the piece being coiled and uncoiled from the eleventh pass to the end of the fifteenth pass. Following the sixteenth and final pass when 4-inch slabs are on schedule, the steel instead of entering the holding furnace is conveyed away from the mill by a roller table to a cold, motor-driven reel and wound into a coil. As delivered to this coiler, the piece measures 400 feet long and 20 inches wide and gages 0.109-inch or about 12 gage.

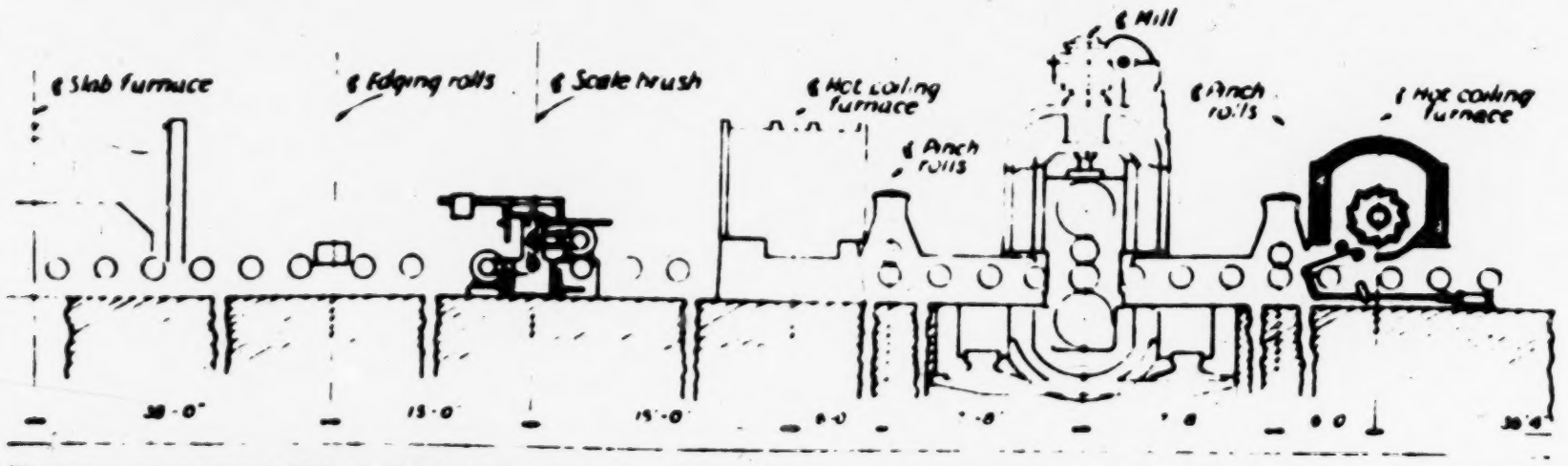
The present mill is only an experimental assembly of apparatus and is not indicative of the full capabilities of this new type construction. The maximum rolling speed possible in the present setup is only 300 feet a minute and will be increased to about three times this speed in the next installation.

Based on the present low speed, a slab 4 inches thick and 9 feet long is converted to strip of about 12 gage (0.109-inch) in 6 to 6½ minutes. A conservative estimate of the effect of three times faster speed would be to reduce this rolling cycle to less than 3½ minutes.

Lighter Construction Suitable

The massive housings and air-cylinder construction over the pinch rolls will not be repeated in any future mill since experimental operation has proven that pinch rolls are necessary merely for manipulating the ends of the piece. This will require only a light weight device instead of the present cumbersome construction, which was provided because of the original intention to exert a heavy pull on the material through the pinch rolls. While motors of 150 horsepower are used on the experimental mill to drive each pair of pinch rolls, only 50-horsepower drives will be employed on future installations.

The product rolled at present has considerably more crown than will be tolerated but the development of this refinement has been postponed purposely to save the expense involved in regrinding and changing rolls. While no edging rolls are used on the experimental setup they will be included in the design of any future mill in order to hold any desired width of product and to break up the initial furnace scale.



Elevation of proposed 48-inch Steckel-type hot mill which employs a single stand of 4-high rolls for converting slabs to strip and holding furnaces for maintaining uniform temperature during reduction

scrap was used in the fabrication, thereby further reducing the costs. It is estimated that the average saving on welded construction was 45 per cent.

All welding was done in the Republic shops using one 600 ampere, two 400 ampere and two 300 ampere machines all manufactured by the Company with which the writer is connected. The shielded arc process of welding using heavily coated electrodes was utilized exclusively. The sizes of electrodes used were 3/16", 5/16" and 1/4".

Hot Rolling—Cold Rolling—Single Stand Mills—Continuous Mills

By A. P. STECKEL
President, Cold Metal Process Company, Youngstown, Ohio.

Presented before the Cleveland District Section of the A. I. & S. E. E., December, 1922.

Your large assembly here this evening results, no doubt, from the interest your membership takes in subjects which have to do with the advancement of all forms of engineering to your industry. I intend to discuss the merits of working with single stand mills, as compared with continuous mills, both in the fields of hot rolling and of cold rolling.

Development of four-high roller bearing mills in the past few years and extensive use of them in sizes from the largest to the smallest, clearly indicates, for the immediate future, a very broad general application of the strip process to the production of all flat products, beginning with plates, and ending only with the very thinnest materials. Such new development means, of course, the abandonment of two-high and three-high hot mills in rolling the wide flat products and also, largely, the abandonment of two-high cold mills, not only in the wider sizes but even down to the very narrowest mills. These developments, in fact, mean nothing but a cure for the weaknesses that were always inherent in two-high mills when employed on wide flat products in hot rolling, and the much more pronounced weaknesses of the two-high mill when employed in cold rolling of all widths.

Up to a few years ago practically all rolling of all sorts, whether hot or cold, was done on two-high mills. For this reason we should not speak too confidently of their abandonment without giving convincing proof of their limitations as well as proof that the mills that are to supplant them have surmounted these limitations. The satisfactory ability of two-high mills to roll rounds, squares, rails, structural sections, and relatively narrow widths of hot strip even in long lengths is well proven, and will doubtless stand, but the two-high mill runs into most serious limitations on wide sections, especially if width occurs in connection with thinness of product. That is, of course, because roll pressures increase directly with the width of product rolled, and also with the hardness of the product. The much greater hardness encountered in cold rolling naturally ran the rolling pressures up tremendously and consequently left no practical means for cold rolling hard metals such as steel except recourse to very low speed.

Fifty years or more ago the inherent weakness of two-high mills as to bending of rolls when rolling wide plates was recognized and cured by a Mr. Lauth who stiffened the mill against roll bending by developing the three-high design. The still better four-high design is perhaps as old as the three-high, but we want to emphasize that both of these old developments aimed only at stiffening the mill against roll deflection, which in fact they did accomplish.

However, in neither the old three-high nor old four-high design was there any aim to raise the possible rolling speed of the mills by doing anything to improve the capabilities of the bearings that carried the rolling load. It should be noted here that both the old three-high and old four-high designs did in fact reduce the unit pressures in the neck bearings, and so did raise the possible rolling speeds that might have been attained, but no notable use was made of this fact because there was no reason for raising the rolling speed in dealing with the relatively short pieces (plates and sheets) that were rolled on the early three-high and four-high mills. One exception to this statement should be noted, this being a disclosure by Mr. Tytus in 1925 as to a proposal to utilize three-high mills to raise rolling speeds somewhat in a hot sheet mill, so as to help obviate the necessity for re-heating in a continuous hot sheet process. It should be said here that a three-high or four-high mill which carries the rolling load on brasses can roll short pieces at speeds which cannot be maintained in rolling long pieces, long enough to be classed as strip. This is because lubrication of brasses can be re-established, and heat of bearings dissipated, when the load is off of the mill between pieces, but such lubrication and dissipation of bearing heat cannot be sufficiently effective for the rolling of more than a certain limited length of piece.

Whatever the facts may be as to the origin of the four-high roller bearing mills, it is agreed that it was the urge of the development of the strip process, and not of the sheet process, that stimulated this recent development.

To focus attention on the one essential of the new strip processes in general, it should be said once for all that the essential feature is the four-high roller bearing mill stand, and that there are two essential features of this essential mechanism. The first feature is the fifty-year old idea of stiffening a mill against distortion by the rolling load. The second

feature is the ability of the mill to perform perfectly at high speed, without any distress from bearing troubles, in rolling the very longest pieces that may be involved.

High speed has, of course, always been an essential in rolling hot strip, so that the four-high mills have not had to raise the speeds employed in hot rolling, but they have vastly increased the possible widths of strip that could be rolled. In the field of cold rolling, the four-high roller bearing mills have not only vastly increased the possible rolling speeds, but have at the same time also greatly increased the possible widths of any given gauge over former practice. Wide thin cold strip could have been produced by four-high mills employing brasses to carry the rolling load, but only by resorting to very low speed. Very little was in fact done on this possible stage of progress before the roller bearing mill, with its higher possible speed, came in to occupy that whole field.

The one physical fact on which these notable advances rest is the ability of a roller bearing, if sufficiently large, to carry very heavy loads at high speeds without troublesome heating or serious wear and upkeep. These bearings themselves could not be applied in heavily loaded two-high mills on account of inherent space limitations. Two-high mills which are not heavily loaded, such as bar mills and hot strip mills rolling the narrowest products, can be fitted with roller bearings with beneficial, though not revolutionary, results. Such mills carry light loads on the neck bearings relative to the loads carried in strip mills, which, by definition and practice, mean mills capable of rolling that material of a width approximating the available space between housings. The space limitations which precluded using roller bearings on two-high strip mills did not apply to properly proportioned four-high mills, and, as soon as this fact was recognized and applied in practice, there was naturally a revolutionary advance in the whole related art.

It is apparent at a glance in comparing the four-high roller bearing stand with the equivalent two-high stand, that the former is very much more expensive. In spite of this fact, and other things being equal, it is still not seriously argued that the four-high stand is not well worth the difference in cost where its use is justified. However, there still remains a wide-spread misconception unfavorable to the four-high mills on the ground of high first cost. This idea dates back to the first wide-spread use of these mills in which they appeared in continuous trains.

It seems well right here to criticize two features unfavorable to continuous mills in general, both these features assuming greater importance as the mills are widened out.

The first feature has to do with the inherent inability of the mill stands to yield a service commensurate with their cost on account of the relatively low speed imposed upon them. This is true in greater or less degree of every stand except the last or delivery stand, which runs at the highest speed. The criticism applies most sharply, of course, to the first stand, which is moving at a very small fraction of the speed of which it would be capable if operated independently of the following stands. It results then, especially in the case of wide continuous hot mills, in multiplying by four, five, six or more the first cost that is necessary to obtain the benefits of four-high operation. This consideration of the inactivity of expensive four-high stands in a continuous mill led me some years ago to contrive to use one single four high reversing stand to do the entire work of the continuous mill; this seeming to be a reasonable undertaking from the fact that the continuous stands were really duplicates of each other, differing only in that the screwdowns of the successive stands were farther advanced with the progress of the piece. The success of such a development would naturally mean a tremendous saving in first cost, and the full speed activity of the one single stand would seem to promise to yield in output a very fair fraction of the capacity of the continuous mill. After experimental development, which took about two years, such a mill was developed to a successful issue somewhat over a year ago. For lack of time, it is not intended to dwell too long this evening on detail discussion of this single stand hot mill, but it seems proper to say that the capacity of such a mill can be stated from experimental data as in excess of ten tons per hour per foot of width. This figure applies to steel rolled to 12 gauge from an initial slab thickness of four to five inches. The weight of single piece practical to roll in this type of mill is easily as great as one ton per foot of width, which is in excess of the weight possible to produce in the existing continuous hot mills.

The ability of a hot mill to produce strip in extraordinarily long lengths has been made important principally by a special requirement of the single stand reversing cold mill. This requirement will be explained later in discussing the cold mill.

The ability of the hot mill to roll pieces of extraordinary length is due to provision for maintaining any desired rolling temperature by keeping the hot strip on coilers in hot chambers close up to the mill on either side. Maintaining in this way any desired temperature throughout the rolling operation not only facilitates the rolling itself, but takes care of special metallurgical requirements of a number of metals such as high silicon steel, monel metal, high carbon steel, brass and extremely low carbon metals of the character of Armco iron.

In addition to holding desired rolling temperatures in the strip, a fortunate result of storage in the hot chambers during the rolling is a pronounced tendency to keep the edges of the material notably hotter than the interior, this being exactly the opposite of the condition in all other hot rolling practice, where radiation is taking place, which naturally results in leaving the edges colder than the interior. It has been found that the maintenance of a high temperature on the edges of the strip in this new type of mill contributes very favorably to preventing the wear of the rolls at the point where the rolls ordinarily cut out first, that is to say, at the part of the rolls that is rolling the edges of the material.

Criticism of this single stand mill has centered principally on the fear that work rolls that are performing the whole rolling operation from slab to finished product would wear out so fast as to make the whole mill impractical. In answer to this criticism it can be said that sufficient work has already

been done on this type of mill to enable us to say that on low carbon steel a pair of rolls will produce a material of good finish after producing sixty (60) tons per foot of width of product of 12 gauge. This would mean in the worst case changing rolls once every six hours when working at normal capacity. This is a conservative statement as to rolls of indifferent quality that have so far been used, and improvement in this respect can be looked for whenever better rolls become available.

It is admitted that rolls must be changed in this mill at shorter intervals than is necessary in a continuous mill. Over against this disadvantage, however, it can be said that when attention is once focused on providing a roll-changing rig capable of changing rolls in a few minutes, which is clearly in sight as a possibility, this objection to the mill on the ground of rapid roll wear very largely fades out. When wide widths of product are to be considered, the only alternative to this mill and a good roll-changing rig is the initial expenditure of extra millions of dollars for a wide continuous mill. The argument then seems to stand in favor of the single stand mill by a very wide margin.

There has been much criticism of this hot mill from some fancied inability to get rid of scale. This criticism can be based upon nothing but the fact that the one only existing mill of this type happens to have none of the ordinary provisions for taking care of initial furnace scale. However, there is no reason for not installing any of the well-known scale devices in connection with these mills, just as they are installed in connection with continuous mills. In fact the advantage seems to lie rather in favor of the single stand mill from the fact that it provides for sharp bending of the material at each pass throughout the coiling operation, thus loosening and throwing off the secondary scale continuously, this feature not appearing at all in continuous mills.

There is no known limitation on this mill, in comparison with continuous mills either as to width or as to the finest gauges possible to roll, the advantage, if any, seeming to be in favor of the single stand mill on account of easy maintenance of desired rolling temperature.

Much of the foregoing criticism of continuous mills applies as well to continuous cold mills, and this consideration had much to do with my preference as early as ten years ago, for developing the four-high cold stand for single reversing operation, aiming at getting high capacity by extraordinarily high speed and correspondingly high power in one stand, rather than to encounter the first cost and prospective operating difficulties of continuous cold stands.

The second general criticism of continuous mills has to do with a consideration just now mentioned, which is the operating difficulty of continuous mills when they attempt to roll difficult sections, by which is meant sections that are wide relative to their thickness. It has long been known that such sections require close following up by adjustment of screwdown, etc. even when rolling in single stands. It was the prospective difficulty of making and maintaining proper simultaneous adjustments in continuous stands that led me to avoid an attempt to employ them on difficult thin sections. From experience of all parties up to date, it seems about time to agree that even outside of the relatively high cost of continuous cold mills, they should be regarded as suitable only for rolling products that are relatively crude and easy to roll. Conversely the single stand cold mill, just as in old two-high practice, should by this time be regarded as able to roll successfully the thin, wide sections much better than the continuous mill.

Since the first mention of general criticisms of the continuous mill, I have been stating general reasons for confining my own developments, both in cold and hot rolling, to the operation of single stands, rather than continuous stands. From here on I will discuss only the single stand cold mill, to which perhaps I have been expected to confine my talk entirely.

The aim in the single stand cold mill development was to realize in the very highest degree the full capabilities of the four-high cold mill by exaggerating all of its inherent merits. The practical aim was to produce tin plate by cold rolling by a cold strip process, cheaper and better than by hot pack rolling, and without arduous labor.

First, to take care of the rolling pressure without distress in bearings at high speed, use was made of very small work rolls to give very small working pressure. With this small work roll diameter was combined an exaggerated backing roll diameter, which should give both unlimited stiffness to the mill and accommodation for roller bearings so large as to run a lifetime at high speed without deterioration. By high speed is meant rolling speeds ranging from a figure above the speeds formerly employed up to speeds of the order of 1500' per minute or more. It was apparent that a limitation on smallness of work roll was imposed by inability of a roll of less than a certain diameter to transmit the necessary driving torque. Since, however, more or less delivery tension is always necessary in cold rolling to yield straight unwrinkled product, a happy solution of the small roll difficulty appeared in letting the delivery tension furnish all the motive power, thus relieving the work roll of torque transmission entirely. This solution of the torque difficulty has enabled us to use work rolls as small as 2" diameter 7" long, 3" diameter 20" long, 5" diameter 38" long; the length mentioned being the length of body between neck bearings. The 2" and 3" diameter rolls are small enough to obviate intermediate annealing in rolling the hardest metals, practically from any gauge down to any other desired gauge, without an intermediate anneal. This cannot be said of the 5" diameter rolls, which, however, enable the rolling of low carbon steel to any desired degree of reduction as in tin plate production, without intermediate annealing.

By way of illustration of the capabilities of these cold mills resulting from the smallness of the rolls they are able to use, it can be said that the very tough stainless alloy, 18% chromium, 8% nickel, has been rolled between 3" rolls from an initial thickness of 1/4" and width of 18" down to .01" thick without an intermediate anneal. With the 5" diameter rolls we have rolled low carbon steel 38" wide from an initial thickness of .080 down to final thickness of .003 without an intermediate anneal. In cold rolling tin plate an initial thickness greater than .080 is not at all objectionable, in fact an initial thick-

pass as great as 33% maximum may, in certain cases, be advantageous.

These performances as to avoiding intermediate anneal, when taken in connection with the widths that have been mentioned, make out a very strong case for the use of small diameter work rolls. When the great length of these rolls relative to their diameter is considered, it will be seen to have been demonstrated that work rolls of these extreme lengths are stiff enough of themselves to obviate the necessity for lateral support such as is provided by so called "cluster" mills. The controlling reason advanced for the cluster design is that it provides a needed lateral support for relatively small work rolls. In answer to this fancied advantage of cluster mills, it should be said here that the four-high design carried to the extremes that have been indicated above, proves of itself that there never is any real occasion to support work rolls in the cluster manner. By this is meant that for any assumed diameter of work roll, and any desired corresponding width of mill, there is always a stiffer mill available of the four-high design than is possible in the cluster design. Stiffness as mentioned above means stiffness in the vertical direction.

As to stiffness in the horizontal direction, and any fancied need for such stiffness, it can be said that no existing four-high mill has ever suffered for lack of horizontal stiffness, even when employing the extreme proportioning of work roll dimensions that we have just been mentioning. We are, in fact, prepared to go much farther in increasing the ratio of mill width to work roll diameter by abandoning, in extreme cases, the neck bearings on work rolls and substituting a babbitted bearing which engages the whole work roll body. Experiments have clearly indicated that this is feasible. When this is done, work rolls small enough to roll the hardest materials without intermediate anneal can be employed on mills of practically unlimited width.

Somehow there seems to be an impression to the effect that this type of cold mill is inherently unable to take heavy drafts, also an impression that the high speed at which it is operated is a controlling factor in rendering it unable to take heavy drafts. This erroneous impression is readily traced back to the fact that some of the earliest mills of this design happened to be used entirely on special materials of extremely light gauges of only a few thousandths of an inch. When, however, the mills were put to work on much heavier products, such as tin plate, motors and gearing were provided for standard reductions of 18% on every pass, and it is an everyday practice on some of these mills to take reductions as high as 30%, aiming always as far as possible to use up the full overload capacity of the motor, in the form of torque or in the form of speed, or of both combined. In answer to all doubts as to limited capacity for drafts, it should be said that these mills are now being put out equipped to employ more horsepower per inch of width of mill than any other cold mills in existence.

We are hearing reportings of some startling performances of cold mills in taking reductions of 50% per pass and the like, but reports of these spectacular performances are not accompanied by equally glowing accounts of the accuracy and uniformity of the gauges of the product so produced, nor of the flatness and generally workmanlike appearance of the product. Viewed historically, it should be remembered that in the old days of necessarily slow speed cold rolling, the only way to increase production was by taking heavier and heavier drafts, up to the point of failure of the mill to make the reduction. However, now since unlimited speed is available, it is no longer to be regarded as a valuable achievement to make spectacular drafts, if in making such drafts any one single adverse effect results, such as failure in accuracy or uniformity of gauge, buckled or wrinkled product, and the like. While on the subject of accuracy of gauge, it should be said first that a mill employing very small rolls and excessively stiff backing rolls is inherently a mill for producing very uniformly gauged material.

Conversely, the worst form of mill to yield uniformly gauged product, especially in thin gauged product, is a mill employing large work rolls. It happens that the spectacular performances just referred to of 50% cold reductions per pass have been on mills employing work rolls of over three times the diameter that we find most suitable. In the light of simple calculation born out by experience, we feel justified in considering heavy drafts and large work rolls to be a vicious combination requiring a maximum first cost of apparatus and yielding in return the poorest practical result. In addition to tremendous first cost of mill structure and bearings to carry the rolling load of unnecessarily large work rolls, the load on bearings runs so high, if heavy drafts are taken on thin material, as to insure the rapid deterioration or destruction of these expensive bearings.

The main disturbing factor in obtaining uniform gauge is the inevitable change of temperature in the mill parts. Up to about two years ago this disturbing factor of varying temperature, with resulting contraction and expansion of the mill parts, necessitated frequent stops to apply the micrometer to the material as a guide in making necessary adjustments. If such stops were not sufficiently frequent, mill temperatures often in the meantime would get out of hand to the point of producing serious gauge variation, or even of breaking the material from excessive drafts, this latter trouble being encountered especially when the gauges were relatively light.

We were hence confronted with the problem of devising means for reading accurately the gauge of the rapidly moving strip, and we aimed at readings accurate to .0001". This degree of accuracy is commonly considered unattainable with the ordinary micrometer, even without the difficulties added by measuring an object that is in rapid motion. The devices that failed are not of interest here, but the device that succeeded deserves description fully, as much because of its rugged simplicity as because of its successful performance.

The principle employed in this device is the old principle employed in sheet mills, of measuring an initial thickness and length, and thereafter observing only the increasing length to determine the decreasing thickness. To have used the bare principle, as in sheet practice, would have told only the average thickness of a long piece, leaving intolerable errors above and below such average still unknown and uncorrected. To surmount this difficulty we contrived not to compare long lengths but to compare

very short lengths, and to make such comparisons continuously by employing a simple differential device.

This device simply indicates errors in any desired relative velocity of the strip entering and leaving the mill, a geared planetary member moving backward or forward to show any error in the desired length of material on the delivery side of mill. Assume that the desired gauge is .010" and that an error of .001" is to be observed. This is an error of one per cent and will hence cause an error of .1" in a length of 10 inches or an error of 1/4" in 25 inches. This latter length is all that need be rolled to produce one quarter inch of motion of the indicator which the operator is observing, and he immediately makes a slight screwdown adjustment to bring the indicator to rest again. The operator works the screwdown adjustment so as to keep the planetary indicator from moving either forward or backward, thus insuring that there will be as little error in desired length as a fraction of an inch in a mile of product. It will be seen that this negligible error in length applies not only to the total length but to all small component parts of the total length. Hence the overall result is to yield a final product that bears any desired ratio of thickness to the thickness of the original raw material. The only micrometer measurement is measurement of thickness of the raw material. It will be seen that errors in measuring the thickness of the raw material affect the final thickness only fractionally. Thus an error as great as .001" in measuring raw material .100 thick produces an error of only .0005" in final product .010" thick.

The overall result of the use of this device, as to gauge accuracy of product, is to enable the production of material at the full speed of the mill and without stopping, with such accuracy as to make any seeming inaccuracy in the product cast as much doubt upon the micrometer as upon the gauge of the material. The other equally important benefit from the use of this device is a vast increase in the capacity of the mill, amounting in the case of fine gauge product to an increase of about 100% in all day capacity.

Once having attained full speed operation of the mill without interruption for applying the micrometer, the cost per ton of cold rolling steel strip for tin plate from .030 to .010" has come down to as low a figure as $3.50 per ton, this cost including direct labor, power, entire roll cost as to first cost and all re-grinding, water, oil, maintaining guides, and all repairs. Upkeep of main bearings over several years of such operation, so far experienced, has been zero.

The preferable initial thickness of pickled hot rolled strip entering the mill for tin plate production is about one tenth inch, and the preferable length of such raw material is in the neighborhood of five to six hundred feet or more.

This mill, from its ability to cold roll readily and cheaply from heavy gauge raw material to fine gauge product, yields two results, both as valuable as they have been unexpected in the cold rolling art. First, the ability to start the cold rolling operation with relatively thick material yields a saving in pickling and hot rolling that is not offset by the trifling extra cost of the first pass or two of the cold rolling operation. Second, the unusual amount of cold reduction that is made economically possible without interposing an anneal, yields a superior metallurgical result after a final heat treatment, this being found to be notably true in the case of full finished sheets, and any other products wanting the best deep drawing properties.

The special requirement of extraordinary lengths of raw material is a peculiarity of this mill, mainly for two reasons: The primary reason is that the high speeds attained on the mill would not be practical, in view of the reversing operation, if high speed were of only momentary or short duration, as is necessary with short pieces. Once having long pieces available, the high speeds can be maintained for long runs between reversals, thus cutting down the idle time of reversals to a tolerable fraction of the total time. Another way to regard the advantage of long pieces is to consider that the operator does precisely as much work on a short piece as on a long piece, his work consisting in slowing down, stopping, screwing down, and starting back again at every reversal. Thus the operator's labor and the lost time are both precisely the same on a small piece as on a larger one, making costs and capacities thus largely dependent on working with sufficiently long pieces.

A secondary reason for preferring long pieces is that the ends of the raw material that are permanently attached to the drums have a certain minimum of waste length which forms an objectionable percentage of the total length when the pieces are short, but a negligible percentage when the raw material is in long pieces such as mentioned above.

While dwelling on this requirement of the cold mill for exceptionally long pieces of raw material, it should be said that this prospective demand for long pieces was one of the reasons for the development of the single stand hot mill, which is inherently able to produce extraordinarily long lengths without difficulty.

The capacity of this cold mill in producing base gauge tin plate strip of .011 is easily one ton per hour per foot of width. Power consumption is about two kilowatt hours per ton of such product if the bare, useful mill requirement only is considered, and about 120 kilowatt hours per ton if power consumption of motor generator sets during idle periods and power consumption of all plant auxiliaries of all sorts is included.

Still another erroneous impression concerning this mill should be corrected. This has to do with the mistaken impression that the mill has economic advantage only in rolling relatively very thin products, where avoidance of intermediate anneals is a great factor. It is true that the mill has become best known for its startling economies in the field of light gauge products. However, its capabilities as to high speed, and accuracy and flatness of product give it an economical field in products as heavy as full finished sheets. To realize these advantages on such heavy products it is admitted that very long pieces of raw material are necessary, but it is expected that our novel hot mill shall produce these necessary long lengths.

A closing remark should be made concerning the electric drive that is used on the single stand hot mill and the electric drive that has been found best for the reversing cold mill. In both cases, the Ward Leonard system for the control of a direct current

NOT

motor has outstanding advantage over all alternatives. Mr. Mohler, who will follow me, happens to have had intimate personal experience in both these classes of drive, and I am very glad to have him present to discuss these matters in the light of his experience.

Electrical Equipment for Steckel Mills

By F. MOHLER
Industrial Engineering Department, General Electric Company, Schenectady, N. Y.

Presented before Cleveland District Section of the A. I. & S. E. E., December, 1932.

After listening to such an able and interesting presentation of this rolling process, by Mr. Steckel, and his description of the precision mills which have made this process possible, I present the following discussion of the electrical equipment with somewhat of a feeling of humility. However, it is indeed a rare privilege to be given the opportunity of discussing the electrical details on the same program in which the mechanical details are presented by the mill builder himself.

The primary object of any rolling mill is to produce steel, but steel for a definite purpose, having definite physical properties. The machine must not only produce the desired product, but must have an output which (even under the present state of competition) will pay a reasonable return on the capital invested. Although these are questions primarily of mill design, the electrical equipment must be fashioned with them in mind.

We have here a mill for producing exceedingly thin strip of very high quality, gauge accuracy, and finish. As Mr. Steckel has explained to you, one of the fundamentals is that of pulling the strip through the rolls. The working rolls are not driven—all power for rolling is applied through the strip itself. Bearing in mind the product, it is obvious that torque must be applied very gradually to the motor which drives the reel during starting and accelerating; otherwise, the strip may be stretched unduly, or even broken, with resultant variations in gauge and possible damage to the rolls.

This fact gives us a clue to the answer of one of the questions in our minds which occurs most frequently. Is a separate generator necessary?

It is commonly granted that the adjustable potential system of motor control, wherein the motor is connected to a separate generator and accelerated

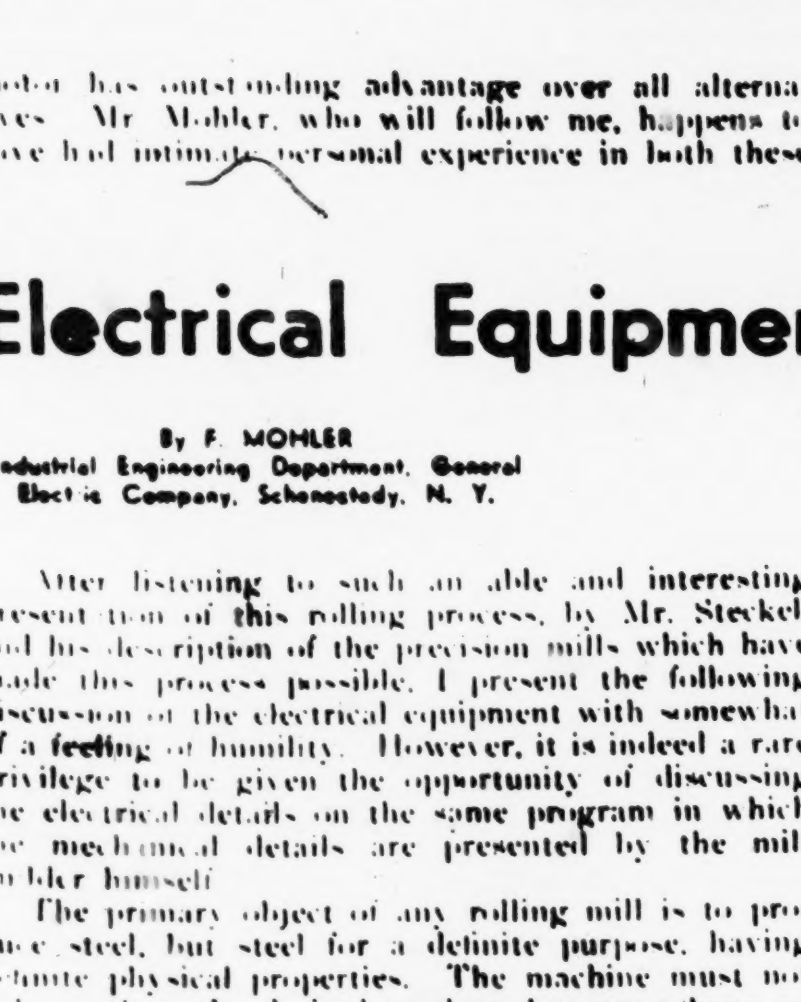


FIG. 1.

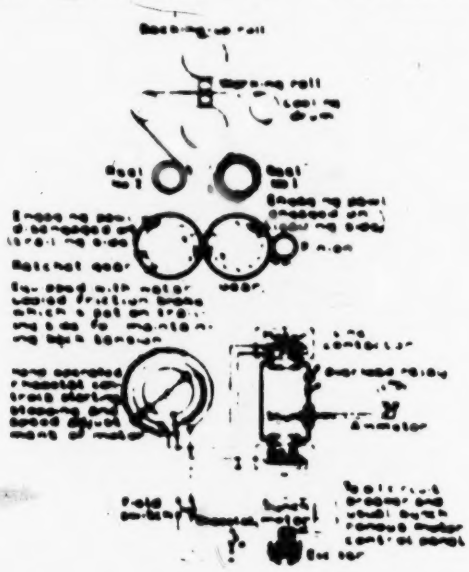


FIG. 2.

by gradually increasing the applied voltage through control of the generator field is the smoothest known method of accelerating. It would require a great number of accelerating points to obtain comparable acceleration with rheostatic starting, whereby the motor is connected to a constant potential source of power through a resistor which is then short circuited in definite steps. Furthermore, because of the length of time required for satisfactory acceleration and the number of reversals necessary, the resistor losses would become quite appreciable.

Other important factors are those of flexibility of control and ease of manipulation. These two factors are conducive to high and economical production. For instance, it is desirable to arrange the equipment so that acceleration may be stopped at any speed for gauging or inspection. Furthermore, if a flaw appears in the strip, the equipment must be stopped very quickly to prevent possible damage to the rolls. In addition, a good operator can tell a great deal about the strip he is rolling by its appear

ance, vibration, etc. From this he determines the rate of acceleration and maximum speed at which he can roll. He learns "the feel" in some mysterious manner and rolls accordingly. In order that he may give his undivided attention to the strip, the operation has been simplified and, as you shall see later on, all control is centered in a single handwheel.

The adjustable-potential system of control lends itself so readily to the foregoing requirements that the additional expense of the separate motor-generator set is considered warranted.

With this as a background, let us consider the actual equipment that is being used for these mills at the present time.

Fig. 1: Here is a small mill driven by a 100 H.P. motor.

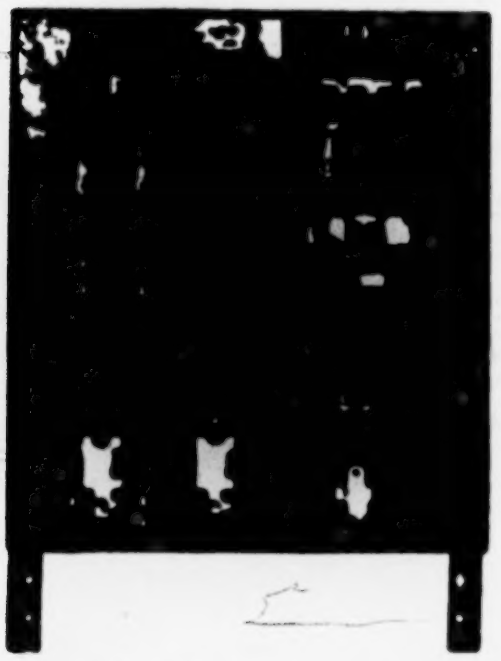


FIG. 1.

The electrical equipment consist of: an adjustable speed d-c. motor; a motor-generator set with direct connected exciter for supplying d-c. power; a control panel; a hand operated combination rheostat for the control of starting, stopping, and speed adjustment of the drive; an ammeter; an exciter field rheostat; and starting equipment for the synchronous motor driving the motor-generator set.

Fig. 2: Before going into the details of the control let us review briefly the gearing and method of driving. It will be noted that the main gears rotate in opposite directions. Therefore, it is not necessary to reverse the direction of rotation of the driving motor but merely to engage one pawl or the other. This is done by a lever which is near the center of the mill.

From the simplified diagram it can be seen that the control of motor speed is obtained through the manipulation of the hand operated rheostat. When it is moved from the "off" position, the line contactor closes, connecting the motor to the generator. Continued turning of the handwheel first strengthens the field of the generator until full voltage is obtained, and then weakens the field of the motor until the desired rolling speed is reached. If the handwheel is turned in the other direction, the motor field is gradually strengthened, then the generator field is weakened, and finally the line contactor is opened. A severe overload will cause the line contactor to open. However, the control is so arranged that the rheostat must be returned to the "off" position before it can be closed again. Furthermore a cemf relay prevents reclosing if there is appreciable voltage across either motor or generator.

The control for the synchronous motor has been omitted because any recognized type of control is satisfactory.

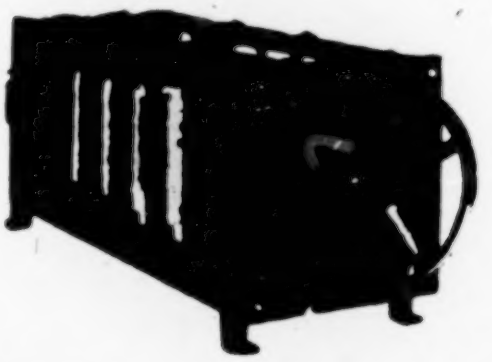


FIG. 4.

Fig. 3: The control devices which you have just noted from the diagram are mounted on a very compact panel. Here is the line contactor, the overload relay, the control relay, the cemf relay and the field and control switch.

Fig. 4: Particular attention has been given to the design of the combination rheostat. The construction is very rugged so as to withstand the severe mechanical and electrical wear imposed by practically continuous operation. Ball bearings and means for lubrication are provided and are arranged in such a manner that the rheostat operates very easily. A large number of points are used in both the generator and motor field sections in order to give small increment changes in speed.

Fig. 5: The rheostat as well as the control panel is placed back of the mill on a common steel structure. The rheostat is connected to the handwheel by a shaft extension. The handwheel is located so the operator can reach it with either hand while observing the strip on either side of the working rolls. On the larger mills where the housing is very wide a handwheel may be placed at either side.

A large ammeter with illuminated dial is placed

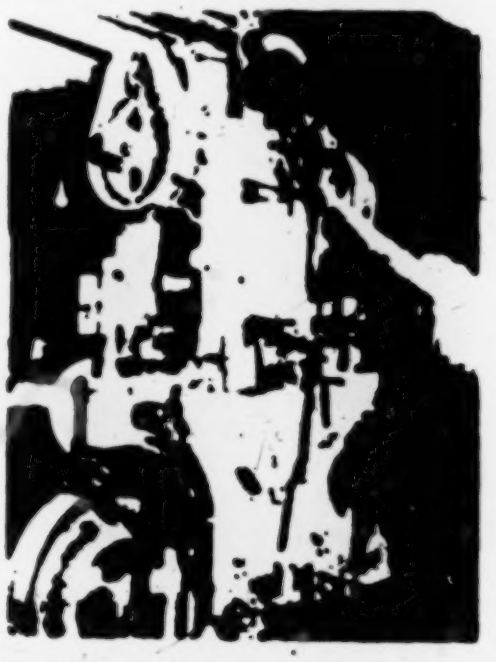


FIG. 5.

on the mill housing for the convenience of the operator in determining the load on the motor, and thereby the approximate tension in the strip.

As the mills increase in size, it becomes necessary to place the driving pinion between the gears

connected to the reels. It follows that the reel gears will operate in the same direction, and it becomes necessary to reverse the direction of motor rotation in order to reverse the direction of rolling. This is accomplished by using reversing contactors for the generator field. These contactors are controlled by a track type limit switch which is operated from the lever which controls the engaging pawls.

Another feature which is desirable on the larger mills, because of the greater stored energy in the drives, is that of dynamic braking. Under any emergency condition, such as a severe overload, which causes the line contactor to open, dynamic braking is applied so that the mill will stop quickly.

Fig. 6: Here is a panel mounting the control devices for these larger reversing mills. You will note that it is practically the same as that for the

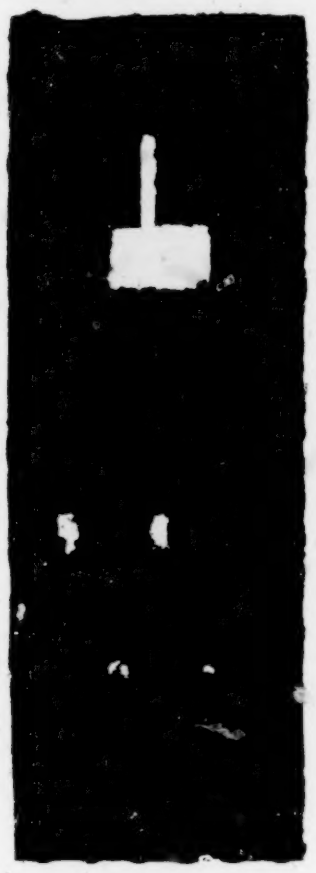
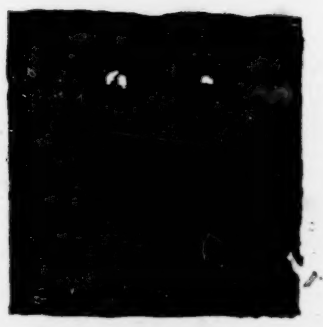


FIG. 6



small mills except for the addition of the reversing contactors and the dynamic braking contactor.

One requirement of this mill, as pointed out by Mr. Steckel, is the use of back tension on the strip.

In general, the power required for hold-back tension is approximately 10% of that required for rolling.

There are two methods of obtaining this hold-back tension—by using friction brakes and by using electric regenerative braking.

The choice, of course, is a question of economy. On the smaller drives the initial cost of the necessary electrical equipment, mechanical arrangement, gearing, etc., greatly outweighs the saving in power obtained. On very large drives, however, the use of regenerative braking may cause an appreciable saving.

In case regenerative braking may prove economical, the following scheme has been proposed. A small drag generator of just sufficient capacity to maintain the desired back tension will be geared to each of the reels. These will be alternately (depending upon the direction of rolling) connected to a booster motor forming a part of the main M-G. set. The output of each generator will be controlled by a constant current regulator so that constant tension is maintained.

After all is said and done, however, simplicity is the watchword for these drives, and it is reasonable to assume, therefore, that the very excellent traction brakes, which the Cold Metal Process Company has developed for the purpose of maintaining back tension, will be used on most of the future drives.

And now a word about the motor—its rating, features, etc.:

I might say at the outset that Mr. Steckel and others of his organization have done considerable in determining from actual tests, the strip pull required for various drafts on the materials rolled in his mills.

Allowable strip pulls, strip speeds, draft and the tonnage to be obtained are so closely related to the mill design that it is quite necessary for the mill builder to either calculate the actual motor required or designate the schedule and strip pulls so that the electrical manufacturer can calculate the root mean square values.

As a matter of fact tentative motor sizes varying from 50 H.P. to 1750 H.P. have already been selected for the various mills and tonnages, but subject to change depending upon the various combinations of the above factors which may be encountered on a particular application.

It has been found that for various schedules the most economical motor which can be used should be capable of taking 150% load during the early passes. Since the early passes are usually taken at full field speed and since these passes are of rather short duration, a mill motor which will meet the NEMA standards is usually satisfactory.

The motors are shunt wound - first, because there is no particular merit in building them compound wound, and second because the necessity of reversing the compound field is somewhat of a nuisance.

So far, there has been no need of forced ventilation, but in view of possible conditions which may arise in connection with oil or acid fumes and the like, it is recommended that the motors be built so that enclosing covers may be added if necessary.

Frequently the question is raised as to WR². I should like to remind you, however, that this is not a fast reversing mill. In contrast, acceleration and deceleration are quite slow as compared to a blooming or a slabbing mill. Furthermore, the passes are quite long. It is believed, therefore, that the slight gain which might be made by using a special motor of low WR² is negligible, and unwarranted from a first cost standpoint.

So much for the motor itself.

I should like to mention briefly one point which may have already raised a question in your minds. Since the motor pulls the strip through the working rolls by winding it up on a reel, it is obvious that the load on the motor will increase in direct proportion to the radius of the coil. When the change in coil diameter is quite appreciable, it may become desirable to use a speed regulator so as to maintain a constant strip speed and thereby a more uniform load on the motor. I have mentioned this point to show that it has been considered, and will be used when deemed necessary.

Before passing on to the reversing hot strip mill, let me leave this thought: the outstanding requirements of the electrical equipment for Steckel Mills are smoothness of operation, ease of manipulation, and simplicity.

The reversing hot strip mill is indeed an inter-

esting subject and one, which if covered thoroughly, would take considerable time. Therefore, I am not going to burden you with the details, but will limit my remarks to a few of the fundamentals.

Mr. Steckel has already described this mill, its purpose, and how a slab is rolled down, as quickly as possible so as to conserve heat, to a thickness suitable for coiling in furnaces located on either side of the working rolls.

So far as the slabbing operation is concerned, it is very comparable to our ordinary slabbing mills. However, there is one important difference. The slab is rather long to begin with and attains considerable length before coiling is started. Thus, the passes last for a reasonably long time, and very little can be gained in the way of reducing peak load demands by using the well-known flywheel motor-generator set and liquid slip regulator, or Illgner system. For this reason, coupled with the saving in first cost, it is recommended that a synchronous motor driven motor-generator set be used for supplying d-c. power for these drives.

There is another point which should be mentioned in connection with the main roll drive. It has been the custom to rate reversing mill drives at 50 deg. C. rise, force ventilated. However, due to the long passes and high sustained peaks, which appear to be in the neighborhood of 200% normal load during the early passes, it is quite desirable to base the drives on a 40 deg. C. rise, force ventilated rating.

Fast reversal of this type mill is not essential and has very little bearing on the production capacity because the time of reversal, acceleration and deceleration is short compared to the time actually consumed in rolling. The omission of the special features usually incorporated for obtaining exceedingly fast reversals reduces first cost and simplifies the control.

On the first reeling pass, it is evident that, even though taken at slow speed, the reel on the leaving side of the mill must be accurately synchronized with the delivery speed of the strip—if it is running too fast the end of the strip may pull out of the blades on the reel or if it is running too slow the strip may cobble between the mill and reel.

It might be mentioned that the pinch rolls are raised on the leaving side because they are only required for entering the piece into the main rolls.

After the reeling operation is started, the mill is accelerated to the maximum allowable speed for that pass. During acceleration the reel must be forced to stay in step with the mill motor. In addition, as the rolling progresses, the diameter of the coil increases and it must be slowed down accordingly. The rate at which the reel motor must slow down depends upon two factors—delivery speed, and the thickness of the strip.

As the end of the piece approaches the mill during the first reeling pass, the mill is decelerated to a slow speed.

The pinch roll on the leaving side is then lowered and it too must be in step with the mill. Just as the end of the piece passes through the mill, but before it passes through the pinch rolls, the mill must be stopped. The mill is then reversed and the pinch roll feeds the strip into the mill. Threading the other reel, etc., is the same process as that just described. In connection with the reel which is now unwinding, it should be noted that its speed must now increase as the coil unwinds. Furthermore, a new problem has entered the picture. The speed of the reel depends on the entering strip speed which no longer corresponds to the mill motor speed, but is slower by an amount equal to the percentage draft.

Complete control of direction of rotation, acceleration, deceleration, and stopping is centered in a hand operated master switch which may be operated from a point in front of either reel, where the operator can see the threading operation of both the mill and the reel, as well as watch the progress of the winding or rewinding operation, as the case may be.

In order to lighten the duties of the operator and save time, it is proposed to use automatic pre-set screwdown control.

However formidable the electrical requirements may seem, it is a matter of fact that we have obtained very satisfactory operation even with rather meagre and developmental equipment on the experimental mill. With the experience gained on this mill we feel confident of the results to be obtained with the proposed schemes of control which will be used on a new drive.

New Year's Statement

▲

By A. W. ROBERTSON
Chairman, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

The contrast between January this year and a year ago is marked. A year ago business was running downhill with the brakes off. Now we are no longer going downhill and in some quarters business has improved substantially, although the general standard of business throughout the country is still very low. The future is uncertain and vague in detail but we can see enough to know that 1933 will be a year of gradually improving business. The most hopeful sign is the improved point of view of industrial leaders. The discouraged have passed out of the picture and men of courage and youth are in command.

Everyone realizes that our economic life would be greatly stimulated by some outstanding discovery which would become tremendously popular, making many new jobs and stimulating business generally. I do not think such development imminent nor do I regard it as essential to recovery. The restoration of our factories, commercial buildings, institutions and homes to anything like first class condition after three years of depletion will in itself provide the stimulus we need. Industrial leaders are beginning to recognize this and are planning programs of rehabilitation and modernization on the basis of insuring future earnings. Storekeepers, landlords and home owners are bound to take part in this move-

Opinion of the District Court.

Filed December 28, 1956.

MODARELLI, District Judge.

This action was commenced by The Cold Metal Products Company, an Ohio corporation, against Crucible Steel Company of America, a New Jersey corporation. Plaintiff's claims are that defendant owes it money for royalties pursuant to a patents' license contract dated September 30, 1946.[1] The opinion and decisions of this court relating to several preliminary motions are reported in 126 F. Supp. 546.

The license contract dated September 30, 1946, covered Cold Metal's Reversing Hot Mill Patents. All of the licensed patents related to methods and equipment for rolling metal ingots such as steel, heated to an elevated temperature, into relatively wide and thin gauged strip in lengths sufficiently long to permit coiling the metal on reels during the hot rolling operation. In 1948 and early 1949, Crucible installed a hot strip mill and began commercially to operate it about April 1, 1949. From that date until November 30, 1951, Crucible paid contract royalties amounting to $655,189.54. One of plaintiff's claims is that additional royalties amounting to $161,668.72 are owed for that period. A second claim is that Crucible owes royalties amounting to $329,226.07 for the period from November 30, 1951, to April 1, 1953, during which period Crucible did not pay any royalties.

In addition to the license contract issue, there are patent issues. Cold Metal alleges that although the

1. The contract was terminated, pursuant to its provisions, on April 1, 1953.

license contract has been terminated, Crucible's continued operation of its mill infringes three of Cold Metal's patents.[2] Crucible contests the validity of the three patents.

COLD METAL'S CLAIM FOR ADDITIONAL ROYALTIES FOR THE PERIOD FROM APRIL 1, 1949, TO NOVEMBER 30, 1951.

1. Crucible computed and paid royalties on hot rolled stainless steel which it later cold rolled, by deducting from the base price of hot rolled stainless steel extra charges for annealing and pickling the hot rolled stainless steel.[3] Cold Metal's claim for additional royalties is based on the argument that Crucible should have used the "prevailing regular market price" required under Section III, Paragraph 4 of the contract but that instead Crucible deducted from that price 4½¢ a pound because the material was annealed and pickled before

2. The licensed patents were:

Patentee	Number	Filed	Granted
Steckel	1,857,670	6 15 27	5 10 32
Keeney & Ferm	1,918,968	1 12 28	7 18 33
Steckel	1,977,214	5 4 31	10 16 34
Montgomery	2,072,121	10 21 33	3 2 37
Montgomery	2,072,122	12 4 34	3 2 37
Montgomery	2,087,065	1 19 34	7 13 37
Montgomery	2,116,121	12 21 35	5 3 38
Montgomery	2,214,107	10 23 36	9 10 40
Montgomery	2,219,150	6 7 37	10 22 40

The alleged infringed patents are:

Montgomery 2,072,122, Claims 6, 10, 18, and 19.

Montgomery 2,087,065, Claims 1, 2, 3, 4, and 5.

Montgomery 2,214,107, Claims 4 and 6 "are invalid for lack of patentable invention" (the only patent which has not expired).

3. The parties have stipulated that the amount involved is $100,351.23.

being cold rolled or fabricated.[4] Crucible agrees that the prevailing regular market price controls, but it argues that such price of hot rolled stainless strip, unannealed and unpickled, intended for further reduction by cold rolling, was the base price less the established extras of 4½c a pound for annealing and pickling.

The court concludes that Crucible's deduction was improper. The prevailing regular market price was the "base price" and that price was for the hot rolled stainless strips and coils in the annealed and pickled condition, no extra having been charged to the purchaser for those operations. It is clear from the evidence that it was the practice in the industry to sell hot rolled stainless annealed and pickled strip at the base price without any charge to the purchaser of an extra for annealing and pickling.[5] The reason there was no such charge was that the hot roller manufacturers insisted on performing those operations to permit them to inspect the material before selling it and thereby avoid later rejections by purchasers.

2. The second contract issue is whether Crucible should have included in its computations, scrap resulting in its Agricultural Department from manufacturing disks and plowshares.[6] In addition to Crucible's Hot Rolling Department it has an Agricultural Department where it manufactures agricultural disks and plow-

4. Section III, Paragraph 4 of the contract does exclude from the royalty formula extras charged to the purchaser for annealing and pickling.

5. Even Mr. Glenn, Crucible's vice-president and general manager of sales, who was called as a witness by Cold Metal, testified that no extra for annealing and pickling was charged when stainless steel hot rolled strip was sold to cold rollers.

6. The parties have stipulated that the amount involved is $46,462.93.

shares. Scrap is produced during the operations, and in computing the royalties due on the hot mill operation, Crucible excluded all that operational scrap. Crucible argues that it is required under the contract only to pay royalties on revenue-producing material. Specifically, Crucible points to Section III, Paragraph 5 of the contract, providing that royalty payments shall be made covering "salable production" which is defined as all material "shipped or used."[7]

The court concludes that the operational scrap which Crucible failed to include in its royalty computations was "used" by it within the meaning of Section III, Paragraph 5. The contract does not exclude all scrap from computations under the royalty formula; the only excluded scrap is defective material rejected by a customer or by Crucible and later used by Crucible as scrap or sold at scrap prices. The court agrees with Cold Metal's argument that it is the weight of the material used, i.e., the weight of good material transferred to and used in the Agricultural Department and the selling price of the material transferred there that is the basis for royalties.

3. The third contract issue is whether Crucible should have included in its computations and paid royalties on scrap resulting from slitting in its Cold Rolling Department.[8] In computing royalties, Crucible excluded the scrap resulting from the slitting of material after it had been transferred from the Hot Rolling De-

7. As to material rejected by Crucible and later used by it for scrap, no royalty is payable and Cold Metal does not claim royalties for such material.

8. The parties have stipulated that the amount involved is $14,591.37.

partment to the Cold Rolling Department. Again, Cold Metal argues the deduction was improper because royalties must be computed on the basis of the weight of the material transferred to and "used" in the Cold Rolling Department. And again, the court concludes that Crucible's deduction was improper for all the material was used by Crucible in its Cold Rolling Department.

4. As to the fourth contract claim, the issue is whether scrap resulting from Crucible's inspection of cold-rolled pickled and annealed strip is includible as a royalty base.[9] Here, unlike the other so-called scrap materials, clearly the scrap is rejected by Crucible. Under Section III, Paragraph 5, such material is excluded from royalty computations.

COLD METAL'S CLAIM FOR ROYALTIES FOR THE PERIOD FROM NOVEMBER 30, 1951, TO APRIL 1, 1953.

Cold Metal's second claim is that Crucible owes royalties for the period from November 30, 1951, to April 1, 1953. Cold Metal contends that each of the Montgomery '122, '065, and '107 patents contains one or more claims covering Crucible's hot strip mill and its operation. Crucible, of course, cannot contest the validity of those patents.[10]

The '122 patent relates to improvements in reversing hot mills. The pertinent claims are Nos. 6, 10,

---

9. The parties have stipulated that the amount involved is $263.19.

10. See this court's earlier opinion, 126 F. Supp. 546, and *Automatic Radio Manufacturing Co., Inc. v. Hazeltine Research, Inc.*, 339 U.S. 827, 836 (1950); *Hall Laboratories Incorporated v. National Aluminate Corporation*, 224 F. 2d 303, 305-6 (CA 3 1955).

18, and 19.[11] The improvements are directed at the difficulty in causing the material being rolled to enter the rolls properly to prevent cambered strip.[12] Also, there had been difficulty in causing the leading end of the material properly to engage the coilers within the furnaces on opposite sides of the mill and frequently the leading end of the piece was bent, making it difficult to cause the material properly to engage the coiler. The patented solution consists of side guides on both sides of the mill, operation of the guides successively to provide a parallel guiding throat on the entering side of the mill and a tapered guiding throat on the other side of the mill. The patent also provides pinch rolls for feeding the material toward the mill and, after passing

11. "6. In a rolling mill including a pair of housings and work rolls journaled therein, pinch rolls on one side of the mill, and means for raising one of the pinch rolls through a short distance, and independent means for raising the upper pinch rolls through a greater distance.

"10. The combination with a rolling mill having a driving motor and a controller for the motor, of adjustable side guides on both sides of the mill, and means operated by said controller for shifting the guides inwardly on the entrance side of the mill and outwardly on the exit side of the mill.

"18. In a rolling mill, a pair of housings having work rolls journaled therein, pinch rolls on at least one side of the mill for engaging material being worked in the mill, means for retracting one of said pinch rolls when unused for a substantial period, and independent means for temporarily retracting one of said rolls.

"19. The combination with a rolling mill and a roll table for advancing work thereto, of pinch rolls on one side of the mill, one of said pinch rolls being retractible, and means for retracting said roll including fluid pressure-operated cylinders and pistons, one of which has a short stroke for temporarily retracting the roll and the other having a longer stroke for retracting the roll when unused for substantial periods."

12. Cambered strip has a sidewise curvature in the plane of the strip. It is an objectionable condition during the rolling operation.

through the mill, toward the coilers, between passes, whereby the strip is properly started on the coilers. The pinch rolls are automatically raised when the strip has been properly started and they are withdrawn when the material being rolled is handled back and forth through the mill in the flat without coiling between passes. (Exhibit P-3, p. 1, col. 1, line 31 through col. 2, line 6). In the patent it is pointed out that after the strip is started through the mill and into the coilers, the pinch rolls are positioned in the low-lift position on the winding and unwinding sides so that the strip is freed of any pinching action between the mill and the winding and unwinding coilers.

The '065 patent relates to a reversing type of hot mill employing both a roughing mill unit and a finishing mill. All of the claims are pertinent. [13] That patent

13. "1. In a method of rolling metal strip, the steps consisting in supplying to a roughing mill a heated slab-like body which is too thick for coiling, rolling the body in the roughing mill until it is substantially thin enough to permit of coiling, but maintaining the thinned body in the flat state, and, in the same heat, feeding the thinned body to a reversing mill, subjecting it to successive passes therein to reduce it to a desired strip thickness, and coiling it between passes in the reversing mill.

"2. In a method of rolling metal strip, the steps consisting in supplying to a roughing mill a heated slab-like body which is too thick for coiling, rolling the body in the roughing mill until it is substantially thin enough to permit of coiling, but maintaining the thinned body in the flat state, trueing the edges in said mill, and, in the same heat, feeding the thinned body to a reversing mill, subjecting it to successive passes therein to reduce it to a desired strip thickness, and coiling it between passes in the reversing mill.

"3. In a method of rolling metal strip, the steps consisting in supplying to a roughing mill a heated slab-like body which is too thick for coiling, rolling the body back and forth in the roughing mill until it is substantially thin enough to permit of coiling, but maintaining the thinned body in the flat state, and, in the same heat,

points out that for certain classes of product it is desirable to provide a finish on the hot strip superior to that which can be obtained with a mill in which the entire reduction from the slab to the thin strip is effected by the same pair of rolls. The patentee, Montgomery, proposed taking a slab after it was properly heated and subjecting it to repeated passes through a roughing mill to elongate it and then passing the material, in the same heat, to another reversing mill with heated furnaces on opposite sides and rolling the material while coiling it between passes. Montgomery also proposed trueing the edges in the roughing mill, cropping at least one end between the rolling on the roughing mill and the rolling on the finishing mill, and continuing the rolling on the roughing mill until the breakdown cools to a temperature below that at which free scale forms. According to the patentee the advantages of the patent are

> feeding the thinned body to a reversing mill, subjecting it to successive passes therein to reduce it to a desired strip thickness, and coiling it between passes in the reversing mill.
>
> "4. In a method of rolling metal strip, the steps consisting in supplying to a roughing mill a heated slab-like body which is too thick for coiling, rolling the body in the roughing mill until the body cools to a temperature below that at which free scale forms, and until it is substantially thin enough to permit of coiling, but maintaining the thinned body in the flat state, and, in the same heat, feeding the thinned body to a reversing mill, subjecting it to successive passes therein to reduce it to a desired strip thickness, and coiling it between passes in the reversing mill.
>
> "5. In a method of rolling metal strip, the steps consisting in supplying to a roughing mill a heated slab-like body which is too thick for coiling, rolling the body in the roughing mill until it is substantially thin enough to permit of coiling, but maintaining the thinned body in the flat state, and, in the same heat, feeding the thinned body to a reversing mill after cropping at least one end of the thinned body to facilitate its entry into said reversing mill, subjecting it to successive passes therein to reduce it to a desired strip thickness, and coiling it between passes in the reversing mill."

that a higher finish is obtained than by using one mill stand for both breakdown and finishing operations because the heavier scale is eliminated from the material before it reaches the rolls on which the finishing operations are performed; also the output of the finishing mill can be increased because the mill can be operated at higher speeds a greater portion of the time than when the breakdown operations are also carried out on the same mill stand.

The '107 patent is a method patent related to the '122 patent. Claim 6 is the only pertinent claim.[14] One of the principal difficulties with the earlier reversing hot mills was they were incapable of consistently rolling a breakdown without camber or longitudinal curvature, making it necessary to permit the breakdown to coil loosely on the winding reel; there was skidding or axial shifting of the turns on the coil being wound with the result that on the next pass, the back tension imparted to the breakdown by the retarding of the unwinding reel caused an edge to strike the side guides and become folded over into a double thickness. (Exhibit P-5, p. 1, col. 1, lines 12-26).

> "In accordance with the present invention, however, I utilize the pinch-rolls only while starting the leading end of a breakdown through the mill and into the coiling reel on the opposite side, the pinch

14. "6. In a method of rolling strip, the steps including passing a breakdown, heated to plastic condition, back and forth between reducing rolls, uncoiling it on one side and coiling it on the opposite side of the rolls, passing an end of the breakdown entirely through the rolls, frictionally gripping said end to feed it back through the rolls, freeing that portion of the breakdown between the mill and the point of coiling, and tensioning such portion uniformly throughout."

> rolls being thereafter retracted, freeing the strip between the mill and the reel. I then apply sufficient torque to the shaft of the winding reel to tension the portion of the breakdown between the reel and the mill. I also apply a back tension to the portion of the breakdown between the mill and the unwinding reel thereby exerting a retarding torque on the shaft of the latter. By thus tensioning the breakdown, I am able to form a tight coil on the winding reel, thus eliminating 'skidding' and preventing cambering of the product during the later rolling passes." (Exhibit P-5, p. 1, col. 1, line 47, to col. 2, line 7.)

The patentee also points out that the guides on the exit sides of the mill prevent cambering of the leading end of the breakdown until it is engaged by the pinch rolls; the pinch rolls assist in guiding the strip until it is engaged by the coiling reel; the guides will correct any incipient camber before the leading end has entered the pinch rolls and the forward tension on the strip will pull out any camber which the mill tends to produce in the breakdown after it has been started on the reel.

Crucible's mill as constructed and operated on October 16, 1951, when the Steckel '214 patent expired (the Keeney & Ferm Patent having previously expired) embodied two details of design and operation covered by claims in the Montgomery '122 and '107 patents. One of these details was the arrangement of pinch rolls on each side of the finishing stand of the hot mill in such a way that the upper roll of each set of pinch rolls could be raised by the operation of pneumatic cylinders from pinch position to either of two positions of retraction.

known as the low-lift and high-lift positions;[15] the other detail was that the deflector rolls located at the entrance to each of the coiling furnaces were driven by direct connected electric motors.[16]

Crucible contends that by making two changes in the construction of the mill, it eliminated the two details covered by the license, thereby excluding all of the mill's production from the license contract. First, the short stroke cylinders which had previously enabled the upper pinch rolls to be withdrawn from the strip to the low-lift position were eliminated so that the pinch rolls thereafter could occupy only two positions: pinch or fully retracted. An entirely separate roll was added, known as the hold-down or auxiliary roll, one on each side of the mill. These rolls were actuated by wholly separate cylinders arranged so that the hold-down rolls could also be in either an up position 12 inches above the pass line or a down position about 3 inches above the pass line. The hold-down function of the suppiemental rolls, Crucible contends, was neither taught nor hinted at in any of the licensed patents. This change, resulting in eliminating the formerly low-lift, high-lift position of the pinch position, was completed on October 29, 1951. The other change in the Crucible mill involved the installation of magnetic clutches in the drives of the deflector rolls. Provision was made for the rolls to be driven by their motors; this prevented them from being warped by unequal exposure to the furnace heat which would have been the result if the rolls were permitted to stand in one position for a substantial length of time. Crucible argues the only licensed patent claim relating

15. See Claims 6, 18, and 19 of Montgomery '122.
16. See Claims 4 and 6 of Montgomery '107.

to the driving of the deflector rolls was Claim 4 of the '107 patent which included the feature of driving the deflector rolls "to prevent frictional drag on the breakdown" during the coiling-rolling operation. But, Crucible contends, it re-arranged its deflector rolls drive in such a way that during the coiling-rolling operation the deflector rolls were disconnected from the motor drive by the operation of the newly installed magnetic clutches; the rolls were rotated during the coiling-rolling operation solely by such frictional drag as was caused by contact between the material and the surface of the roll. This, according to Crucible, was exactly the way the corresponding deflector rolls had been driven in the expired Steckel '214 patent. The installation of these magnetic clutches was completed on November 19, 1951.

The result of the installation of the magnetic clutch was that each deflector roll was driven when strip was not being rolled, but the drive was interrupted during rolling operations involving coiling so that only the strip served to drive the roll. This change, however, did not affect the operation of the mill. As to the modification of the pinch rolls the result was that the cylinder for attaining the low-lift position was hydraulically operated rather than air actuated. Here, too, however, the change made no operational difference.

Each of the specifications in Claim 6 of the Montgomery '107 patent was followed in Crucible's modified mill. The Crucible mill passes a breakdown, heated to plastic condition, back and forth between reducing rolls, uncoiling it on one side and coiling it on the opposite side of the rolls; an end of the breakdown is passed

entirely through the rolls and frictionally grips the end to feed it back through the rolls; that portion of the breakdown between the mill and the point of coiling is freed; finally, that portion of the strip between the mill and the point of coiling is tensioned uniformly throughout.[17]

In addition to Claim 6 of Montgomery '107, the Crucible mill is covered by Claims 6, 10, 18, and 19 of the Montgomery '122 patent. As to Claim 6, Crucible's auxiliary roll is movable through a short distance to provide the low-lift position; the upper pinch roll is movable by independent means through a greater distance to provide the pinch and high-lift positions. Thus, Crucible having used the substance of that claim, its mill is covered by the claim. *Graver Tank & Mfg. Co., Inc., et al v. Linde Air Products Co.*, 339 U.S. 605, 607, 608 (1950); *Kellett Autogiro Corp., et al v. Brohan*, 24 F. Supp. 81 (D.C. N.J. 1938). As to Claim 10, Crucible's modified mill has a driving motor for the four-high mill and a controller for the mill motor; it also has side guides on both sides of the mill and means operated by the mill motor controller for shifting the guides inwardly on the entrance side of the mill and outwardly on the exit side of the mill. As to Claims 18 and 19, it is clear from Mr. Sachs' testimony[18] that Crucible's mill is covered by those claims.

Crucible's mill also is covered by the five claims of the Montgomery '065 patent. As to Claim 1, "a heated slab-like body which is too thick for coiling" (Transcript, p. 399) is supplied to a roughing mill; where it

17. Mr. Valette, Crucible's expert, so testified.
18. Transcript, pp. 573, 574, 575.

is rolled "until it is substantially thin enough to permit of coiling" (Transcript, pp. 400, 423-425); this is done while "maintaining the thinned body in the flat state" (Transcript, p. 400); "in the same heat" (Transcript, p. 400); the thinned body is fed to a reversing mill where it is subjected to successive passes to reduce it to the desired strip thickness and where it is coiled between passes (Transcript, pp. 400-401, 800-801). Claim 2 differs from Claim 1 only in that Claim 2 includes the step of trueing the edges of the roughing mill —and this too is done in Crucible's modified mill (Transcript, p. 401). Claim 3 differs from Claim 1 only in that Claim 3 specifically includes rolling the body back and forth in the roughing mill, which is also done in Crucible's mill. (Exhibit D-3, pp. 5-6). Claim 4 specifies that the material is rolled in the roughing mill until it cools to a temperature below that at which free scale forms; this also is done in Crucible's mill (Transcript, pp. 802-807, 814). Claim 5 differs from Claim 1 only in that Claim 5 specifies that the material is fed to the reversing mill after cropping at least one end of the thinned body to facilitate its entry into the reversing mill. And this too is part of Crucible's mill (Transcript, pp. 401, 799, 808).

Both parties have stipulated that the royalty amount in dispute for the period from November 30, 1951, to April 1, 1953, is $329,226.07, and the court finds that Crucible owes this amount to Cold Metal. The court also has decided in favor of Cold Metal on the license contract issues involving annealing and pickling ($100,351.23), the blanking of disks and plowshares ($46,462.93), and slitting scrap ($14,591.37). Thus,

the total amount Crucible owes to Cold Metal is $490,631.60 plus interest.[19]

VALIDITY OF PLAINTIFF'S PATENTS

The flash of genius test has been extinguished and Cold Metal has the benefit of a presumption of validity even though this court "* * * is left to the struggle to determine upon which side of a vague boundary line it will place the alleged invention * * *." *R. M. Palmer Company v. Luden's, Inc.*, 236 F. 2d 496, 500 (CA 3 1956). The burden of establishing the invalidity of the patents rests upon Crucible. *Hartford National Bank & Trust Company v. E. F. Drew Co., Inc.*, 237 F. 2d 594, 596 (CA 3, 1956). And commercial success of any disclosures in a patent is evidence of invention. *Palmer v. Luden's, Inc.*, supra; *Hartford National Bank & Trust Company v. E. F. Drew Co., Inc.*, supra.

The Montgomery '065 patent has been held invalid by the Court of Appeals for the Sixth Circuit. *Cold Metal Products Co. v. Newport Steel Corp.*, 226 F. 2d 19 (CA 6 1955). That court held that "In view of the then state of the art, we think that the particular mechanical arrangements disclosed by the patents in suit represented nothing more than a felicitous selection of known elements, none of which contributed in combination any new or unusual function, and that the subject matter as a whole would have been obvious at the time the claimed inventions were made to persons having ordinary skill in the art of hot rolling metals. 35 U.S.C.A. § 103." That decision, of course, is not binding upon this

19. The court's decisions of the license contract issues result in a dismissal of Crucible's counterclaim for overpayments of $9,479.15 and $4,661.00.

court, although it is entitled to great weight. *Standard Brands, Inc. v. National Grain Yeast Corp.*, 101 F. 2d 814 (CA 3 1939), affirmed 308 U.S. 34 (1939).

This court having independently judged the issue of validity, finds the '065 patent invalid. The five claims of the patent all are limited to a method of rolling a heated slab-like body in a roughing mill until it is substantially thin enough to permit coiling, and then in the same heat feeding the thinned body to a reversing finishing hot mill and subjecting it to successive passes to reduce it to the desired thickness while it is being coiled between passes. All of the claims are alike except for details such as trueing the edges of the material in the roughing mill, rolling in the roughing mill until the material cools to a temperature below that at which free scale forms, and end cropping the material before passing to the finishing mill. But the idea of using a roughing mill as a prelude to finish rolling on a reversing coiling hot mill was not new to the art. See Keeney & Ferm '968 and Steckel '214. Even the Cushwa Patent No. 904,605 applied for on August 18, 1905, and issued on November 24, 1908, for a Method of Rolling Sheet Metal disclosed a multi-stand finishing mill.

Claims 6, 10, 18, and 19 of the Montgomery '122 patent are valid. Claims, 6, 18, and 19 relate to a rolling mill with pinch rolls on at least one side of the mill and mechanism for operating them for shifting into one of three positions: pinch, low-lift, and high-lift. The Steckel '214 patent taught only the pinch and high-lift positions. These Montgomery claims added entirely new functions. For example, in the low-lift position the strip is free to enable the coilers and uncoilers to provide uniform tension on the strip. Furthermore, when the

pinch rolls are in the low-lift position they hold the strip inside the side guides, preventing cambering. Additional functions are that damage to the strip is minimized as it strikes the side guides, sidewise movement of the strip is limited, and uniformity of tension is maintained. As to Claim 10, it relates to a controller for a driving motor of the rolling mill with side guides on both sides of the mill, the controller being used for shifting the guides. Crucible contends that this claim is invalid because it is completely anticipated by Steckel '214. But in that patent the side guides are moved by frictional engagement with the table rollers which are driven through shafts and gears by the rolls (the pinch rolls are driven by motors controlled separately from the mill motor). The guides disclosed by Montgomery maintain the strip in the center of the mill and on the entrance side they prevent cambering.

Cold Metal also complains that Claim 6 of the Montgomery '107 patent has been infringed. Crucible not only questions the validity of Claim 6 but also seeks a declaratory judgment that Claim 4 is invalid and not infringed.[20] Claim 6 is invalid. It describes a method of rolling strip by passing a heated breakdown back and forth between reducing rolls, the uncoiling and coiling occurring on opposite sides of the rolls; the end of the breakdown is frictionally gripped and fed back through the rolls and the material is uniformly tensioned.

20 "4. In a method of converting a slab or ingot into strip, the steps including passing a slab back and forth in the flat between reducing rolls to form a breakdown, passing the breakdown back and forth between reducing rolls to form a strip, winding the breakdown on a coiling reel between passes through the rolls, bending the breakdown about a guide roll, and driving said guide roll to prevent frictional drag on the breakdown."

Steckel '670 provides for tensioning hot strip by means of coiling reels, and Keeney & Ferm '214 discloses tension between the mill and the coiler. Since the court finds that there is no substantial difference between Claim 4 and Claim 6, Claim 4 also is invalid.

INFRINGEMENT

There is no issue as to Crucible's infringement of the claims of plaintiff's valid Montgomery '122 patent. Crucible admits that "* * * the construction and operation of defendant's mill * * * were likewise the same during both time periods [the period of the license contract and the period after its termination]."[21] Thus, it is unnecessary for the court again to discuss the construction and operation of Crucible's mill and whether it is an infringement of Cold Metal's valid patent, and the court finds that defendant has infringed upon claims 6, 10, 18, and 19 of the Montgomery '122 patent. The issue of damages shall be referred to a Special Master who will be guided by 35 U.S.C.A. §§ 283, 287,[22] unless the parties can agree by stipulation.

The question of costs and reasonable attorneys fees to the plaintiff will be considered later after hearing counsel on these issues.

The foregoing opinion shall constitute findings of fact and conclusions of law as required by Rule 52.

An order may be submitted in conformity with the opinion herein expressed.

---

21. Defendant's Brief after Trial, p. 11.

22. As to the court's power to refer the issue of damages to a Special Master, see *Modern Art Printing Co. v. Skeels*, 123 F. Supp. 426, 434, reversed on other grounds, 223 F. 2d 719 (CA 3 1955).

Judgment of the District Court.

This action, having come on to be heard on the pleadings, proofs, briefs, and arguments submitted by the parties and the Court having rendered an opinion constituting its findings of fact and conclusions of law, it is hereby Ordered, Adjudged, and Decreed as follows:

1. Plaintiff, The Cold Metal Products Company, under the license agreement dated September 30, 1946, shall recover from defendant, Crucible Steel Company of America, royalties for the period from April 1, 1949, through November 19, 1951, in the principal amount of $146,210.38, together with interest upon those royalties at the legal rate of 6% upon each increment of the royalties from the date each increment was due until the date hereof, that interest amounting to the sum of $53,359.89; the total principal and interest amounting to $199,570.27; and the Clerk is directed to enter judgment in favor of the plaintiff and against the defendant for this amount.

2. Plaintiff, The Cold Metal Products Company, under the license agreement dated September 30, 1946, shall recover from defendant, Crucible Steel Company of America, royalties for the period from November 20, 1951, until April 1, 1953, in the principal amount of $334,942.07, together with interest upon those royalties at the legal rate of 6% upon each increment of the royalties from the date each increment was due until the date hereof, that interest amounting to the sum of $88,259.24; the total principal and interest amounting to $423,201.31; and the Clerk is directed to enter judgment in favor of the plaintiff and against the defendant for this amount.

3. Allowance has been made, with plaintiff's consent, in the recovery allowed in the preceding paragraph for an overpayment of royalties amounting to $9,479.15, for which defendant sought recovery in Paragraph 10 of its original answer and counterclaim filed February 16, 1953, as amended, March 23, 1956.

4. Allowances having been made in the recovery allowed in Paragraphs 1 and 2 for the royalties amounting to $5,716.00 accrued from November 20, 1951, to November 30, 1951, for which recovery was sought in Paragraph 11 which was added to defendant's counterclaim by an amendment filed March 23, 1956, that counterclaim is hereby dismissed.

5. Claims 6, 10, 18, and 19 of U. S. Letters Patent No. 2,072,122 are valid.

6. Each of Claims 6, 10, 18, and 19 of U. S. Letters Patent No. 2,072,122 has been infringed by defendant by the use and operation of its hot strip rolling mill from April 1, 1953, to March 2, 1954.

7. Claims 1 through 5, inclusive, of U. S. Letters Patent No. 2,087,065 are invalid.

8. Claims 4 and 6 of U. S. Letters Patent No. 2,214,107 are invalid.

9. Plaintiff shall recover from defendant damages adequate to compensate it for defendant's infringement of Patent No. 2,072,122 from April 1, 1953, to March 2, 1954, which damages shall in no event be less than a reasonable royalty for defendant's use made of the invention of that patent, together with interests and costs as may be fixed by the Court; and this action is hereby referred to DONALD A. ROBINSON, ESQ., as Special

Master, to ascertain, state, and report to the Court an account of and to assess against the defendant such damages as the Master finds plaintiff is entitled to recover from defendant by reason of defendant's infringement of that patent.

10. Plaintiff shall recover from defendant its taxable costs relating to the contractual and infringement issues, excepting the costs of preparation of the drawings, Exhibit P16-1 through P16-23, the costs of which shall not be taxed, and neither party shall recover any costs relating specifically to the validity of the patents in suit. Plaintiff's costs as aforesaid shall be taxed by the Clerk pursuant to the Rules of this Court.

11. Neither party shall be allowed attorney's fees.

12. In respect of any and all relief prayed for in defendant's supplemental counterclaim and in plaintiff's counterclaim not specifically covered herein, those counterclaims are hereby dismissed.

13. This judgment is intended as a final judgment despite the reference of the damage issue to a Master, there being no just reason for delay, and the Clerk is hereby directed to enter judgment in accordance herewith.

s/ ALFRED E. MODARELLI
Alfred E. Modarelli
United States District Court
Judge

Dated: February 8, 1957.

Order Amending Judgment.

Upon the consent of the parties, paragraph 3 of the judgment entered herein on February 13, 1957, is hereby amended by striking out the words "in the preceding paragraph" from line 2 thereof and substituting the words "in paragraph 1."

A. E. MODARELLI
U. S. D. J.

Dated: February 18, 1957

Consented to:

WILLIAM H. WEBB
Attorney for Plaintiff

CHARLES H. WALKER
Attorney for Defendant

Entered: February 18, 1957

Notice of Appeal by Crucible.

Original Filed Feb. 18, 1957.

NOTICE IS HEREBY GIVEN that Crucible Steel Company of America, defendant above named, hereby appeals to the United States Court of Appeals for the Third Circuit from paragraphs 2, 5, 6, 9 and 10 of the final judgment dated and filed February 8, 1957 and entered in this action on February 13, 1957.

PITNEY, HARDIN & WARD
By FRANK C. O'BRIEN
Attorneys for Defendant
500 Broad Street
Newark, New Jersey

CHARLES E. KENWORTHEY
REED, SMITH, SHAW & McCLAY
Union Trust Building
Pittsburgh, Pennsylvania

RAYMOND J. McELHANNON
225 Broadway
New York 7, N. Y.

CHARLES H. WALKER
RONALD F. BALL
20 Exchange Place
New York 5, N. Y.
Of Counsel

February 18, 1957

Notice of Appeal by Cold Metal.

NOTICE IS HEREBY GIVEN that The Cold Metal Products Company, plaintiff above named, hereby appeals to the United States Court of Appeals for the Third Circuit from Paragraphs 7 and 8 of the final judgment, dated and filed on February 8, 1957 and entered in this action on February 13, 1957.

O'MARA, SCHUMANN, DAVIS & LYNCH

By EDWARD J. O'MARA

1 Exchange Place
Jersey City 2, New Jersey

WEBB, MACKEY & BURDEN

By WILLIAM H. WEBB
MORTON BURDEN, JR.

1220 Farmers Bank Building
Pittsburgh 22, Pa.

Attorneys for Plaintiff

No. 6880

DEC 2 1957

JOHN T. FEY, Clerk

United States Court of Appeals

FOR THE THIRD CIRCUIT

Appeals Nos. 12216 and 12217

THE COLD METAL PRODUCTS COMPANY,

Plaintiff, Appellant,

v.

CRUCIBLE STEEL COMPANY OF AMERICA,

Defendant, Appellant.

APPENDIX TO CRUCIBLE'S BRIEF

FRANK C. O'BRIEN
Pitney, Hardin & Ward
500 Broad Street,
Newark 2, New Jersey
Attorney for Defendant

CHARLES E. KENWORTHEY,
Reed, Smith, Shaw & McClay,
Union Trust Building,
Pittsburgh 22, Pennsylvania.

RAYMOND J. McELHANNON,
Ward, Neal, Haselton,
Orme & McElhannon,
225 Broadway,
New York 7, N. Y.

CHARLES H. WALKER,
RONALD E. BALL,
Fish, Richardson & Neave,
20 Exchange Place,
New York 5, N. Y.
Of Counsel

INDEX

Portions of the Transcript of Proceedings

PAGE

Opening statement for plaintiff 1b

William R. Howell:

Direct 1b
Cross 3b

William Bruce Lockwood:

Direct 3b
Cross 4b
Direct (Recalled) 41b

Ralph A. Freed:

Cross 6b
Recross 31b

George Sachs:

Cross 33b

William H. Colvin:

Direct 36b
Cross 40b

Leroy Valette:

Direct 41b
Cross 76b
Redirect 77b

DEFENDANT'S EXHIBITS

		PAGE
D 1	Charts	
	Fig. 1 2-High Mill	79b
	Fig. 2 4-High Mill	80b
	Fig. 3 Universal or Roughing Mill	81b
	Fig. 4 The Keeney & Ferm Mill (adapted from Fig. 1 of Keeney & Ferm Patent No. 1,918,968)	82b
	Fig. 5 The Steckel '214 Mill (Based on Fig. 4 of Steckel Patent No. 1,977,214)	83b
	Fig. 6 Crucible Hot Strip Mill, 4-High Reversing Mill Stand & Coilers	84b
	Fig. 7 The Pinch and Flattening Rolls and the Coiler of Montgomery '122 (Taken from Fig. 4 of Montgomery Patent No. 2,072,122)	85b
	Fig. 8 The High Lift-Low Lift Cylinders of Montgomery '122 (Taken from Fig. 6 of Montgomery Patent No. 2,072,122)	86b
	Fig. 9 Crucible Hot Strip Mill, 4-High Reversing Mill Side Guides	87b
D 3	Description of Apparatus and Operation of the Crucible Mill	89b–128b
	Separate index of description	91b
D 5	Drawings of Crucible's Hot Strip Mill	129b–155b
	Separate index of drawings	129b

PAGE

D- 7 5-panel Fold-out Chart re Montgomery Patent '065 ..... 157b

D- 8 4-panel Fold-out Chart re Side Guide Control, Claim 10 of Montgomery '122 ..... 159b

D-9 4-panel Fold-out Chart re Double Lift Pinch Roll, Claims 6, 18 and 19 of Montgomery patent '122 ..... 161b

D-10 5-panel Fold-out Chart re claims 4 and 6 of Montgomery '107 ..... 163b

D-21 *The Evolution of the Wide Strip Mill* (describing the Butler mill) by Stephen Badlam, published in the Year Book of the American Iron and Steel Institute of 1927 ..... 165b–170b

Portions of the Transcript of Proceedings

OPENING STATEMENT FOR PLAINTIFF

[4] Mr. Webb: For the subsequent period, that is, from November 30, 1951, to April 1, 1953, it paid nothing at all, on the theory that it had modified the mill to some extent, and that the mill was outside the scope of the patents in that period.

Now, we don't contend that Crucible is liable for [5] any royalties in that particular period, unless one or more of the claims of one or more of the licensed patents covered the mill, or its operation, during that period.

* * *

WILLIAM R. HOWELL (WORKS MANAGER OF CRUCIBLE'S MIDLAND PLANT)

[213] *Direct Examination by Mr. Webb:*

Q. Mr. Howell, were you in on the discussions leading to the modification of the pinch roll setup on your 4-high reversing mill? A. I was in several of them.

Q. And would you give me the sequence of events, was it decided that you were going to try to get away from the payment of royalties by modifying your pinch roll structure, and then you started out thereafter to find some way of modification; was that the sequence? A. Mr. Webb, I think you will remember a clause in the agreement between Crucible and Cold Metal which identified one of the basic patents, upon the expiration of which the royalties were to be cut 50 per cent. There is another sentence in that paragraph which reads that Crucible will only be liable insofar as the mill has jurisdiction over several of the claims in the remaining patents. That was [214] enough of a challenge to us to explore the matter very thoroughly with our oper-

ating, engineering and counsel. That was the sequence which led up to the changes.

Q. So that the way in which I have stated it was correct; namely, that in the top level management, of which you are a part, the decision was reached to try and avoid the patents and then ways and means were sought through the operating or engineering personnel to try to avoid the patents, is that correct? A. I don't know whether the choice of words as you use them—avoid the patents—was the correct thing. I have shown that your agreement stated, and it was understood by both parties, that insofar as the mill to which we are referring operated under the jurisdiction of the patents royalties were chargeable. But if it didn't operate under the claims of the patents, royalties were not payable.

Mr. Webb: Now, will you read my question?

The Court: He thinks the word "avoid" has a sinister connotation.

Mr. Webb: Will you please read my question?

The Court: If he said "evade" the patent, I think then it would have the sinister connotation which Mr. Howell has in mind.

Mr. Webb: Yes.

The Court: Avoidance isn't usually bad in the [215] law, it is evasion that is bad.

Mr. Webb: I wonder if you would read the question to Mr. Howell. I don't believe he answered it at all. We have no quarrel in regards to the terms of the agreement, Mr. Howell. The agreement speaks for itself. So you don't need to tell us what is in the agreement. We can read. But I would appreciate it if you will try to answer this question.

Mr. Walker: I think Mr. Howell would appreciate it if you wouldn't attempt to tell him what he thought, but ask him to phrase himself how he thought.

(Question read.)

A. Yes.

* * *

[217] *Cross-Examination by Mr. Walker:*

Q. I am going to read a sentence from Section 3, Paragraph 8 of the agreement between the parties and ask you if this is the sentence that you had in mind and referred to in your answer to Mr. Webb a few minutes ago. It reads: "It is understood and agreed, however, that the royalty payments specified herein are to continue only so long as Crucible's mills and equipment or operations are covered by unexpired claims of the Cold Metal patent, and this irrespective of the duration of this agreement." Is that the sentence you had in mind? A. Yes.

* * *

WILLIAM BRUCE LOCKWOOD (COLD METAL'S PRESIDENT)

[225] *Direct Examination by Mr. Webb:*

Q. Does the Cold Metal Products Company manufacture any hot roll strip? A. No, we have no hot roll strip manufacturing facilities.

* * *

[264] *Cross Examination by Mr. Walker:*

Q. Is it true, Mr. Lockwood, that at the present time there is no one in the United States who is paying royalties to your company for the operation of a reversing hot strip mill? A. I think that is correct.

Q. And there are operating in the United States at the present time the following reversing hot strip mills, in addition to the one in issue in this case: first, there is such a mill at the McLouth Steel's Livernois Avenue plant? A. Yes.

Q. That was a mill that was originally operated under license under certain patents from your company? A. Yes.

Q. And the McLouth Company was held by the Circuit Court of Appeals for the Sixth Circuit to be not required to pay royalties for the operation of that mill from and after 1940? [265] A. I know there was a certain date, I don't recall that definitely, but I know there was a certain date.

Q. That date was the date on which you made your settlement agreement with U. S. Steel? A. I don't recall.

Mr. Webb: We will agree that that is correct, Mr. Walker.

Mr. Walker: About the end of August, 1940?

Mr. Webb: August 30, 1940.

Mr. Walker: Yes.

Q. And then another such reversing hot strip mill that is being operated in this country without royalty to you is that of the Newport Steel Company? A. Yes.

Q. Which was the subject of the recent decision of the Sixth Circuit Court of Appeals holding invalid the only three patents that were charged to be infringed? A. Did you mention a patent number?

Q. I didn't mention a patent number, I said three patents. A. That is correct.

Q. The only three patents that were charged to be infringed were held to be invalid, is that right? A. Yes.

Q. Then there is a mill of the Byers Company, against which you have a suit pending, but which has never taken a [266] license or paid you any royalties? A. Yes.

Q. Then there is a mill in Texas of the Lone Star Steel Company against which you have made an informal claim, but against which you have not brought suit and which has not paid royalties? A. Yes.

Q. Does that exhaust the list of reversing hot strip mills in this country, so far as you know them? A. I think that is the complete list.

Q. Where is Mr. Montgomery these days? A. I think he is in California.

Mr. Webb: Mr. Walker, you evidently omitted from your list the McLouth Trenton Mill, with which I am sure you are familiar, since that is involved in litigation.

Mr. Walker: No, I didn't omit it, Mr. Webb. I was speaking as of the present time, and my information is that the mill is no longer either in operation or in this country.

Mr. Webb: I am sorry, the mill was taken out recently, that is correct.

Mr. Walker: I will supplement the questions.

Q. There was, until comparatively recently, another reversing hot strip mill in this country, namely that of the McLouth Steel Company at its Trenton plant? A. Yes.

[267] Q. That mill was operated without license from your company and is the subject of litigation between your

company and McLouth, which is presently awaiting decision before judge Levin in Detroit? A. Yes.

Q. That mill—that was brought, incidentally, as a declaratory judgment suit by McLouth against your company? A. It may have been, I don't definitely recall that that was the character of the suit.

Q. I can assure you that it was because I brought it. A. Well, I wouldn't doubt it.

Q. And involved in that suit are charges of infringement by your company by that mill of McLouth of some six patents? A. Yes.

Q. Including the three patents here in suit? A. I will take your word for it but I don't definitely remember.

Q. And the Steckel '214 patent? A. Again I can't remember.

Q. And the Keeney & Ferm patent? A. I presume that is correct, but again I cannot definitely remember.

Mr. Webb: I will agree that is correct.

Mr. Walker. And there is one other I can't recall what it is. It is another Montgomery patent.

[268] Mr. Webb: Montgomery '121 patent.

Mr. Walker: Montgomery '121. That's all.

* * *

RALPH A. FREED (COLD METAL ENGINEER)

[412] *Cross Examination by Mr. Walker:*

Q. Do you happen to have any illustration, Mr. Freed, of the reversing coiling hot mill on which you worked at the [413] Briar Hill Works of the Youngstown Sheet & Tube Company? A. Do we have any drawings of it, you mean?

Q. Any illustration of it? I think possibly if you don't this one will serve. I will have to ask you about that.

Does this drawing that I show you illustrate schematically, at least, the reversing coiling hot mill which you worked on at the Briar Hill Works? A. Yes, very close schematically.

Mr. Walker: I will ask that that be marked Exhibit D-1.

(Received in evidence and marked Exhibit D-1.)

* * *

[420] Q. In the Crucible mill the work is apportioned between just two millstands, the finishing reversing stand and the roughing mill, in direct accordance with the Steckel suggestion? A. That is correct.

Q. Are you sufficiently familiar with the continuous hot mills that were in commercial use in the area in 1930 to [421] 1935 to tell us whether or not it was conventional in such mills to have roughing mills in line with the finishing mill connected by a roll table so that the material was first rough rolled in the roughing mill and then fed on into the finishing mill and there finished at the same heat? A. That was true; a typical installation of that was the so-called Butler mill.

Q. Yes. But in about 1926? A. I don't know the date.

Q. Consisting of a roughing part of the mill with one or more roughing mills and a finishing part of the mill, consisting of, I think, four in that case, finishing stands, perhaps five, perhaps six? A. That is true.

* * *

[427] When you operated that mill at Briar Hill was the coiling reel drive of such a character as to impose tension on the strip between the coiling reel and the mill proper? A. Yes.

Q. Was the rotation of the unwinding reel retarded in some way so as to impose back tension on the strip between the unwinding reel and the mill? A. It was, yes.

* * *

[430] Q. What, if any, difference or distinction do you draw between front and back tension as it exists in the Briar Hill mill or in the Crucible mill and that referred to in Steckel patent 670, tab 1 of Exhibit D-2, where Steckel says, beginning line 56, "Each coiler is motor driven and may be operated at such a rate as to maintain the delivered strip under tension"? A. I don't get the meaning of your question.

[431] Q. Well, you are familiar with Steckel patent 670, are you not? A. Yes, I am.

Q. Do you have a copy of it there? A. No, I don't happen to have a copy of 670.

Q. I will give you a copy of the binder, Exhibit D-2. The patent is at tab 1. It shows a reversing hot strip mill involving coilers in furnaces on each side of the mill stand, doesn't it? A. Yes, sir.

Q. So there is no doubt that strip is hot as distinguished from the cold strip you were discussing a moment ago? A. Yes, sir.

Q. Now look at page 1, Column 2, beginning line 56, where the patent says, "Each coiler is motor driven and may be operated at such a rate as to maintain the delivered strip under tension." And my question to you is: What, if any, distinction do you draw between that kind of tension and that kind of tension which you said exists in the Briar Hill mill and you have said exists in the Crucible mill? A. I would say it was the same.

Q. Did the Briar Hill mill have at the entrance to its coiler furnaces a roll located in a position corresponding to

that occupied by what you have been calling the [432] deflector roll in the Crucible mill; namely, in such a position as to protect the strip from being drawn against the bottom of the furnace? A. Yes, sir; it did.

Q. In that mill what function was performed by that deflector roll? Did you call it a deflector roll there? A. Primarily that was installed to, purely and simply, protect the strip from coming up against the metal, or sharp corners in that. But then after we had it in operation a while we discovered, inadvertently, that it was causing us something else that was very beneficial, especially on your low carbon steel. We noticed that there was considerable of scale would be down on the table in under that roll. So that we found it was playing a very important part in that steel, that as the secondary scale would be forming, as it was flexed around there, and wound up, it was causing that secondary scale to crack and a lot of it would fall off.

So immediately we felt that that was a very good feature because it assisted in keeping the surface of the strip better, and protected the roll. So immediately we called it a scale breaker roll, which is the name that we have referred to it for years.

Q. Is there any significance to the fact that in [433] describing that roll in the Crucible mill you call it a deflector roll whereas for years you have called it a scale breaker roll? A. I have no knowledge why the name was changed, unless it just would be the engineering department, down at United, when they designed the mill, the man that designed that particular part put that name down on it as a deflector. Other than that I wouldn't know.

Q. How about your own terminology, in your own circles, do you still refer to it as a scale breaker roll? A. I always do, yes, because that is the one name that I am more familiar with than anything else.

Q. You haven't heard any discussions, or participated in any discussion, to the effect that now that Steckel patent 214 has expired it would be better to call it by some other name? A. I have not, no.

* * *

[458] Q. I am going to be questioning you, Mr. Freed, with reference, if you care to follow in the patent, with reference to claim 6 of Patent 107, and I am going to ask you to look at D-1 and each clause of the claim, tell me whether that is descriptive of the apparatus shown in this mill, Exhibit D-1. Does D-1 involve a method of rolling strip? [459] A. It does.

Q. And does it include the steps of passing a breakdown, heated to plastic condition, back and forth between reducing rolls? A. It does.

Q. Uncoiling it on one side and coiling it on the opposite side of the rolls? A. That's correct.

Q. Passing an end of the breakdown entirely through the rolls? A. That's correct.

Q. Frictionally gripping said end to feed it back through the rolls? A. Correct.

Q. That frictional gripping is by the pinch roll on the entry side? A. That's right.

Q. And then does D-1 involve freeing that portion of the breakdown between the mill and the point of coiling? A. Yes.

Q. What happens to free it, in D-1? A. The pinch rolls on that side would be lifted up off of its pinch position.

Q. Was that the operation at Briar Hill? A. After the strip was in the furnace and started to coil [460] in there it was lifted up on the delivery side, yes.

Q. Do you mean the delivery side or the entry side? A. Well, the side between the mill and the coiler.

Q. Well, let's go back and get a starting place here. A. All right.

Q. Frictionally gripping said end that has been passed entirely between the rolls to feed it back through the rolls. That is the pinch rolls on what is at the moment the entry side? A. That's right.

Q. Now, in the Briar Hill installation, after that action had been performed, did the pinch rolls remain closed or were they opened up so as to free that portion of the breakdown between the mill and the point of coiling? A. On the original Briar Hill mill, I am not certain just what that operation was of those pinch rolls, just when they were raised.

Q. Now, what about the pinch rolls on the delivery side in the operation that we are examining, did they stay closed and serve to feed the leading end of the strip up into the opposite coiler—— A. They did.

Q. —or were they apart? [461] A. In the first rolling they were kept down to feed the end of the strip up into the coiler.

Q. Did they stay in the pinch position throughout that pass or was the upper pinch roll retracted so as to free that portion of the breakdown between the mill and the point of coiling? A. I am not positive—the Briar Hill installation—as to when they were lifted up off of the strip.

Q. And then the concluding phrase of the claim, "and tensioning such portion uniformly throughout," did that occur in the Briar Hill mill? A. It did, yes.

Q. On both sides of the mill, that is to say, between the mill and the coiling reel and the mill and the uncoiling reel? A. We had difficulty in maintaining it, but we tried to, and our result was to tension it by either slowing or increasing the speed of those coiling reels.

Q. Now, in that mill, in such instances as the pinch rolls were retracted, or either of the pinch rolls was retracted, during a coiling operation, were they retracted far enough to free the breakdown between the mill and the coiler, or uncoiler, as the case may be? A. If they were retracted, they would be far enough to free it, yes.

[462] Q. So that there was this difference between that operation that you have just described and the operation of the original Crucible mill; namely, that when the pinch rolls of the Crucible mill were retracted to low lift position they weren't freed from the strip, but, on the contrary, bore down on the strip and assured that it would be maintained at a level below the level of the upper flanges of the side guides? A. Yes, those pinch rolls kept the strip down in that position.

Q. And that is in contrast to the action described in connection with Exhibit D-1, where the retraction of the pinch rolls was such as to free them from the strip? A. If and when the pinch rolls were lifted off of them they would be considerably higher than your Crucible mill.

Q. Now, in the Crucible original installation, with the pinch rolls in low lift position, was the upper pinch roll driven? A. In the Crucible mill?

Q. Yes. A. Yes, sir.

Q. In synchronism with the table rolls? A. Yes, sir.

Q. So that if the drive was perfect, perfectly synchronized, the contact between that pinch roll and the [463] strip would not interfere with the uniform tensioning of the strip all the way from the mill rolls to the winding reel, or the unwinding reel, as the case might be? A. If everything was in perfect condition, perfectly synchronized, that would be pretty much the truth, yes.

Q. Now let's compare that with the situation in the Crucible mill as presently operated. There the thing relied

upon to hold the strip down, below the level of the upper flanges of the side guides, is the hold-down or auxiliary roll, as distinguished from the pinch roll, is that right? A. Yes, sir.

Q. And that auxiliary or hold-down roll in the present Crucible mill is not driven, is it? A. No, sir.

Q. So that to whatever extent the driving of an otherwise undriven roll by the strip itself serves to create any inequality of tension in the strip between the mill and the coiling or uncoiling reel, such inequality is present in the Crucible mill as presently operated, isn't it? A. If it is, you would never be able to measure it, it would be so slight.

* * *

[469] Q. What kind of side guides did the mill have at Briar Hill? A. We tried out four or five or six different types of side guides on that mill, endeavoring to get a set that we would consider would be satisfactory.

Q. Did you have in use at all side guides like those in Stecker Patent 214? The best picture of them, I think, is at Fig. 6 of that patent. It is the tab 3 of Exhibit D-2. A. Yes, we tried them.

Q. Was it true of those guides that they were set closer together on the entry side and further apart on the exit side? A. As I recall, yes.

Q. Indeed, that has been true of all the side guides you have ever used on these mills, hasn't it? The entry guides are closer together, almost touching the edges of the strip and the guides on the exit side are opened up a little to prevent jamming as the end of the strip comes through the mill? A. Yes, sir.

Q. And it has always been necessary, hasn't it, in these mills to reverse the positioning of those guides when the

direction of travel of the strip through the mill is changed? A. That is necessary.

Q. It has always been true, you have always had to do it, [470] right? A. Yes, sir.

Q. Is the particular guides of this Steckel Patent 214, wasn't it so that the reversal of positions of the side guides, so that they would be close together on what was going to be the entry side and further apart on what was going to be the exit side, was accomplished automatically when the direction of travel of the strip was changed? A. The position of the guides was governed by the direction in which the table rolls were going, that friction would either cause them, by linkage, to open up or close in.

Q. So the operator didn't have to think about it at all, he just did whatever he had to do to dictate to the motor which direction it should run in, and then start it in that direction? A. Reversed his mill table.

Q. And the guides took care of themselves and went into the appropriate position by reason of the frictional contact they had with the table rolls? A. That is right.

Q. Now, would you look at and keep in mind those Steckel side guides as I read you claim 10 of Patent 122 in suit, and tell me, as I pause after each clause of the claim, whether or not the Steckel side guides and arrangement are described by the claim "The combination with a rolling mill [471] having a driving motor and a controller for the motor"—Steckel 214 had that, didn't it? A. Yes, sir.

Q. "—of adjustable side guides on both sides of the mill"—? A. Yes, sir.

Q. "—and means operated by said controller for shifting the guides inwardly on the entrance side of the mill and outwardly on the exit side of the mill—"? A. There was no control directly connected to the side guides; it was merely as you reversed the mill, reversed the table, the

frictional resistance on there would cause them to go in or out, but there was no separate drive to your guides.

Q. Well, the table rolls were, themselves, the means for moving the guides inward on one side and outward on the other side of the mill? A. Yes, sir.

Q. And those means, the table rolls, were under the control of the motor controller, weren't they? A. Right.

Q. Now, you apparently have in mind some possible distinction between that kind of an arrangement and what there is in the Crucible mill, do you? A. I have none.

Q. So that claim is equally applicable, just as applicable [472] to Steckel 214 as it is to Crucible? A. Except that Crucible has a positive drive to your side guides, where this does not.

Q. Positive as distinguished from frictional, you mean? A. Yes, sir.

Q. You are not thinking about separate electrical connections, are you? A. They are set up down there where it can be manual or controlled with the mill, on your Crucible.

Q. What is it in the Crucible mill that causes the side guides to reverse their position into positions appropriate for travel of the strip in the different directions? A. Now when he reverses his mill, his controller, through his electric hoo[illegible]p, will cause the motor to revolve and either cause the side guides to go in or come out, according to the direction on which side of the mill it is.

Q. You have looked at the operator's instrument pa[illegible]l and control desk down at Crucible? A. I have.

Q. There are two such panels? A. Yes.

Q. One is known as the operator's panel and the other known as the assistant operator's panel? A. That's right.

* * *

[473] Q. How is the Crucible mill stopped at the end of a pass during the coiling operation? A. He centers his control.

Q. Who does? A. I am not sure in your operation down there whether it is such setup where it is all controlled by the one man or whether both men can stop the mill, depending upon the direction. I am not sure of that setup.

Q. Well, there is a motor controller on the operator's desk, isn't there? A. Yes.

Q. Is there one on the assistant operator's desk? A. I am not positive whether there is or not, no.

Q. Which of the two men stops the mill? A. I do not know.

Q. What action of what man is it which actuates the side guides in the Crucible mill? A. It should be the man that reverses the mill.

Q. Well, is it? A. I don't know.

Q. What movement of what switch causes the side guides to reverse their position in Crucible mill? A. Now or——

[474] Q. Now? A. —or when it is set up manually?

Q. Now. A. The only control that I would know would be the one that controls the direction of the mill, other than that I wouldn't know.

Q. Has your experience been more mechanical or electrical, or has it been part of each? A. It is by far more mechanical than electrical.

Q. See these two lights on Judge Modarelli's bench? A. Yes, sir.

Q. You see the little switches, a switch on each light, so that one can, if he wishes, turn them on or off independently? A. Yes, sir.

Q. Would you consider that it would require any great ingenuity to so wire the lights that the pushing of a single switch will light both lights? A. No, sir.

Q. Do you see anything different in principle between that and so wiring up a rolling mill that when you change the direction the side guides are changed? A. It is not a difficult job, no, sir.

Q. It calls for no more than routine engineering? A. That's right.

* * * *

[477] Newark, N. J.

Thursday March 29, 1956

(TRIAL RESUMED PURSUANT TO ADJOURNMENT)

RALPH A. FREED, resumed the stand.

The Witness: Your Honor, I would like to have your permission to make some comments on some of the testimony that I gave yesterday.

The Court: Well, is it in the nature of correction of testimony?

The Witness: It is, sir. After last night —

The Court: You answered my question. You want to correct your testimony.

The Witness: I do, sir.

Mr. Walker: It is the first I heard of it. Of course, I want the witness' testimony to be something he vouches for. It is up to your Honor how you will handle it. I suppose if he is going to do it anyway, it would be better for him to do it now than on redirect.

The Court: Yes. I think it is more practical to do it now than to wait and then go all through it again.

[478] This is the first time I have had such a request. I have had people who wanted to correct their testimony before Grand Juries. I have never had it in the trial of a cause, Mr. Freed. We do want your honest opinion. We want the truth as you know it. So you may correct it now, subject to any objection that Mr. Walker may make, if he thinks one is in order.

The Witness: Last night, when I read over the transcript of the testimony I gave yesterday, I noticed that there were several of the answers that I gave to some of the questions that put the wrong interpretation on the operation of the experimental hot mill out at Brier Hill Steel, and I thought it was advisable to get that cleared up as soon as possible.

Of course, I was not present at all the demonstrations, or all the rollings, and everything, that was done on there. So what I would like to give is that part of it that I know I saw and actually worked with.

The Court: I was under the impression that you were only telling us that, anyway.

The Witness: I was, to the best of my ability; yes, sir.

The Court: All right.

[479] On Page 127 of App. 7b]

The Court: You gentlemen watch it because I don't have my copy here.

The Witness: The first question that Mr. Walker asked, as shown on that page

"When you operated that mill at Briar Hill was the coiling reel drive of such a character as to impose tension on the strip between the coiling reel and the mill proper?".

My answer was, "Yes."

In fact, that could not have been possible on that mill because during all the rolling, where any coiling was taking place, we kept the pinch rolls down on the strip. It was not released during the rolling process. Therefore, that would impose a pressure between the mill and the coiling reel so that the tension would vary between the mill and the pinch rolls and the pinch rolls and the coiling reel.

The second question was:

"Was the rotation of the unwinding reel retarded someway so as to impose back tension on the strip between the unwinding reel and the mill?"

My answer was: "It was, yes."

The Court: Is that the same page?

The Witness: The same thing applies there, that pinch roll—

The Court: On the same page?

[480] The Witness: The same page, yes, sir.

The Court: What was that page?

The Witness: 427a. [App. 8b]

Mr. Walker: Would your Honor like a copy?

The Court: I have it now, thank you.

The Witness: The same thing applied there, the pinch rolls being in a pinch position on the strip would not permit tension direct from the mill to the coiling reel but would break it up between the two.

On Page 431a [App. 8b] down almost to the bottom of the page, where the long question comes in

"Now look at page 1, Column 2, beginning line 56, where the patent says, 'Each coiler is motor driven and may be operated at such a rate as to maintain the delivered strip under tension.' And my question to you is: What, if any, distinction do you draw between the kind of tension——"

Mr. Walker: That kind of tension.

Mr. Webb: That kind of tension.

The Witness: "—that kind of tension which you said exists in the Briar Hill mill and you have said exists in the Crucible mill?"

The point there is, as I explained in the other questions, the Briar Hill mill has the pinch rolls on the strip which breaks up the tension between the reel and the mill, while on the Crucible mill the pinch rolls, or the [481] hold-down, is released so the tension is uniform, direct from the reel to the mill or from the mill to the reel. It is just a little different type.

Then on page 459, [App. 10b] about the third question up from the bottom of the page, Mr. Walker asked:

"And then does D-1—" that is the big chart here that shows the Briar Hill mill— "then does D-1 involve freeing that portion of the breakdown between the mill and the point of coiling?"

Again the pinch-rolls are down on the strip and held there in that place.

The next question:

"What happens to free it, in D-1?"

The answer was: "The pinch rolls on that side would be lifted up out of its pinch position."

Well, in fact they were not lifted up off, and I just want to clarify that they were kept on during all of that time.

On page 460 and 461, [App. 10b-12b] I won't read those questions and answers, but it all applies to the same principle as to whether the pinch roll goes down. So as to make it clear, all during the rolling of the strip where it was being coiled in the furnaces, the pinch roll was being kept in contact with the strip at all times during the rolling there at Briar Hill Steel, as far as I have any knowledge of it.

[482] I think that is the extent of the comments I wish to make, sir.

The Court: All right, sir.

Cross-Examination (Continued) by Mr. Walker:

Q. When did you for the first time observe any mill operation in which the pinch rolls were retracted so as to free the strip after the pinch rolls had served their function of feeding the strip into either the mill or a coiling reel? A. It would either be Dominion or McLouth; I don't recall now just which of those two plants I saw in operation first, because they were both coming along at practically the same time, but it would be either one or the other.

Q. Would you state what that time was, as accurately as you can? A. I would say it was in late '35 or early '36.

[483] Now, I would like to understand a little more fully than I do what you mean when you say that the pinch rolls engaging the strip between the mill and the point of coiling, or uncoiling, broke up the tension. I think that was your phrase. A. If you had a coiling reel that is overrunning, or running just a little faster than the mill, and there was nothing to interrupt it in between, it would exert uni

form tension from the reel to the mill. But if in the meantime you put a pair of pinch rolls, or anything pressing down very severely on the middle of that strip between the mill and the reel you would have considerable different tension, as we noticed out there at Briar Hill, because occasionally, if things were not being just absolutely a hundred per cent synchronized, the reel would feed off just a little faster than the mill could be taking it away, and being held there by the pinch rolls it would have a tendency to want to fold up, and loop, and get wavy between the reel and the pinch rolls, while it would still be tight between the pinch rolls and the mill. That was one of the conditions we had to try to overcome.

Q. Perhaps this will help develop the point. I show you Steckel patent 670, which is at Tab 1 of Exhibit D-2. There a mill is shown, and a coiling reel in a furnace on each side. [484] A. Yes, sir.

Q. And is it not your understanding that those coiling reels were so driven so as to maintain tension upon the strip between the mill and the winding reel, and the mill and the unwinding reel? A. I wouldn't know what his thought was in those early stages, but you would have to—if the reels are driven there would have to be at least tension between the winding reel and the mill.

Q. Well, I call your attention to that part of the text beginning at page 1, Column 2, line 56, reading, "Each coiler is motor driven and may be operated at such a rate as to maintain the delivered strip under tension."

Doesn't that mean to you, when taken in conjunction with the fact that the strip between the two reels and the mill touches nothing whatever in the way of either pinch rolls, or deflector rolls, or anything else, that the strip on each side of that mill is maintained under uniform tension?

A. It would not necessarily be under uniform tension, because the pressure exerted on those rolls would interfere with the tension that is set up by the coiling reel.

Q. I am sorry. I don't follow you. I thought you said a moment ago that it was the interposition of the pinch rolls on the Briar Hill mill that broke up the tension [485] and that if the strip from the mill to the coiling reel, for example, was not in contact with any roll then the tension imposed by the winding reel would be uniform all the way from the coiling reel to the mill. That is what you said, isn't it? A. Yes, from the coiling reel to the mill.

Q. Yes. Now, isn't this Steckel patent 670 a perfect example of that kind of situation, the strip not being in contact with anything all the way from the mill to the coiling reel? A. Now you are considering the tension just between the reel and the mill.

Q. That's right. A. Yes, sir.

Q. That's uniform all the way, because the strip touches nothing and there is nothing to alter the tension, to make the tension be different at any one point as compared with any other point in that length of strip? A. No, sir.

Q. You mean you agree with me? A. Yes.

Q. Then between the mill and the uncoiling reel is not the situation the same, that it is under tension if the coiler is driven in such a way as to put it under tension and that tension is uniform in the strip all the [486] way from the unwinding reel to the mill? A. That is true.

Q. And indeed it was one of the features of the claims of that patent, the last phrase of Claim 2, "maintaining the metal under tension between the rolling thereof and the coiling thereof." A. I don't know anything about it. I am not familiar with that.

Q. Now, starting with the understanding—and I will confine this, for simplicity, to the delivery side of the mill

where the reel is serving as a winding reel—if we have the strip untouched by anything from the mill to the coiling reel, and the coiling reel is driven so as to impose tension, it necessarily follows that that tension will be uniform all the way from the coiling reel to the mill. Are you with me so far? A. Yes, sir.

Q. Now, if we interpose or put in contact with the strip on its way from the mill to the coiling reel a roll such as the deflector roll and we drive that deflector roll by an external source of power at precisely the speed at which the strip is moving, then that deflector roll will not break up in any way the uniformity of tension which existed before the roll was put there. Do you agree with that? [487] A. Yes, sir.

Q. If, on the other hand, that same deflector roll is not provided with an external source of power but requires for its driving force some force transmitted to it by the passing strip then it would interfere with the uniformity of tension and result in a tension on one side of the deflector roll being one value and on the other side of the deflector roll a different value, is that right? A. I doubt if I could 'theoretical enough to go into such a fine point, because it would be so infinitesimally small, if it did exist, that to any practical purpose and extent I certainly wouldn't be able to state whether it did or did not, it would be so slight.

Q. Then would it be your view that anyone who claimed that it was a measurable advantage to put a drive on an existing deflector roll like that was exaggerating the situation, to say the least? A. I wouldn't know, except they might think it would be highly advisable.

Q. Well, I don't follow you.

The Court: Do you see any advantage to be gained by that deflector roll tension, sir?

The Witness: The tension—no, sir; none.

The Court: Well, that is what Mr. Walker is [488] trying to find out, isn't it?

Mr. Walker: I think it is clear. He says that maybe there is a theoretical advantage to driving it, but it is so small that you can't measure it. And I guess we were at that point yesterday. But I am using this merely as a transition to consider what the effect is of the pinch rolls being interposed.

* * *

[503] Q. I am going to shift now the discussion to the Crucible mill after the changes, which involves the same pair of pinch rolls, but now equipped to have only a high lift or up position 12 inches off the strip and at the bottom no position other than a complete pinch position. You have that in mind, do you? A. I do.

Q. All right. When that pinch roll of the Crucible mill is dropped on to the strip, it drops the full 12 inches, doesn't it? A. It does; yes, sir.

Q. As distinguished from the one and a half inches [504] that it dropped when it went into the pinch position on the original mill? A. That's correct.

Q. So that as presently constructed the Crucible mill does not enjoy the advantage that you attributed to having a high lift and low lift position that when the pinch roll dropped on to the strip to go into the pinch position it didn't have to fall that great distance and hit the strip, and dent it, and maybe even break the bearings, is that right?

* * *

[505] A. On the Crucible mill the hydraulic cylinder that operates the raising and the lowering of that pinch roll is a Logan cylinder, made by the Logan Manufacturing Com-

pany, and it has what they call cushions on both ends. So it is a standard type of cylinder, so that you get your full, quick stroke down so far and then your main port is closed, and then there is only a very little, itty-bitty bit of a port that can be adjusted, that lets the air out slowly for a short space, so that it comes down close, like that, and then the rest of the distance.

Now, that cylinder that they use can be so adjusted to come down and cushion it so it would not give that terrific impact to the dropping of the 12 inches.

Q. I guess perhaps I will have to break it up, since you haven't answered it. Is this true, Mr. Freed, that one of the important advantages that you claimed for the provision of a low lift position as distinguished from just a high position and a pinch position for the pinch rolls was that when you dropped the pinch roll all the way from a full retraction on to the strip you dented [506] the strip, and banged the rolls, and sometimes even broke the bearings of the table roll? A. That is true of the original experimental mill at Briar Hill-Steel; we found that condition did exist; yes, sir.

Q. And it was to get rid of that, that was one of the main purposes of putting in this low lift position, right? A. Yes, sir; it was.

Q. And with that low lift of only an inch and a half you found that when you dropped the pinch roll from that low lift position on to the strip that you didn't have that trouble of denting and breaking? A. No, we eliminated considerable of that. And then we also found that we gained a lot of other advantages that were unlooked for.

* * *

[507] Q. Now, insofar as that particular advantage, having a shorter travel so as not to have such an impact

when the pinch roll was closed to the pinch position, Crucible's present arrangement doesn't take advantage of that particular feature, does it? A. They take advantage of it in a little different way, by cushioning that cylinder so that it only comes down with full force so far, and the last little portion of the cylinder it is slowed down to get away from that impact. That is a standard type cylinder.

Q. But the descent that the roll makes is the 12-inch full travel that you were trying to get away from in providing a low lift position? [508] A. The total stroke is, yes.

Q. Now, you said that this cushioning effect in this hydraulic cylinder, and you volunteered the name of the supplier—as a matter of fact, it isn't even a hydraulic cylinder, is it; it is an air cylinder? A. Air cylinder.

Q. Yes. Now, another advantage that you mentioned as flowing from the provision of a low lift position was that being a shorter stroke it didn't consume as much time to make the travel, is that right? A. That is true.

Q. Now, so far as that advantage of a high lift-low lift position is concerned, does the Crucible mill as presently designed and operated enjoy that advantage? A. No, under the present setup they do not.

Q. They still have to take the time to make the full 12-inch travel. Now, another advantage that you attributed to that high lift-low lift arrangement of Montgomery's that I had in mind was that by reason of the counteraction of the cylinders for the full travel and the cylinder, or cylinders, for the short travel, there was a sort of cushioning effect involving the entrapment of part of the air, and so on, is that right? A. When which cylinder was operating when? I don't just——

[509] Q. Well, you tell me. Didn't you claim that there was some cushioning effect present in the Montgomery high lift-low lift arrangement when the pinch roll was in

the low lift position? The question at the moment is, did you tell me that, did you state that in your testimony? A. Yes, I believe I did.

Q. And the thing that you were talking about can be seen in Fig. 6 of the patent, Patent 122. That's at Tab 5. A. That's, in general, the arrangement of the lifting cylinders, yes.

Q. And the cylinders at each end are the long stroke cylinders—— A. That's true.

Q. —provided to give the high lift position? A. Yes, sir.

Q. And the cylinders just inside of those outer cylinders, the short ones, marked 82, are the cylinders and pistons provided to give the low lift position, is that right? A. That's true.

Q. And would you explain how this cushioning effect which is present in the Montgomery low lift position is achieved? A. If you will turn to our drawing No. 7, that shows the [510] pinch roll operation, it is much easier explained, because it is colored and very recognizable.

The Court: That is in the plaintiff's drawings?

The Witness: Yes.

Mr. Walker: That's right. It is drawing No. 7 of their set.

The Witness: Now, your Honor, I went through this all very carefully yesterday.

The Court: I know you did yesterday.

The Witness: Now I suppose I should go through it again for him.

Q. Well, you don't need to, if you will follow my question and answer it. I have already asked you if it wasn't so and you went off the subject. Isn't it so, that the cushioning action in the low lift position of Montgomery is

achieved by reason of the fact that air cylinders are used and that the air in the large cylinders is imprisoned and consequently serves as a sort of flexible or yieldable buffer that makes that cushioning effect? A. That is true.

Q. Yes. Now, in the Crucible mill the roll which you said corresponded to the low lift position of Montgomery is the hold-down roll, isn't it? A. That is so called, a hold-down roll, yes.

[511] Q. And that is in a position three inches above the strip instead of an inch and a half as the predecessor low lift position was? A. That is right.

Q. And that hold-down roll of Crucible's present mill doesn't have any such cushioning action as the Montgomery low lift pinch roll had, does it? A. Not to as great an extent as an air cylinder; no, sir.

Q. It doesn't have any cushioning effect because it has got a hydraulic cylinder and hydraulic fluid is incompressible, isn't it? A. Not a hundred per cent. There is always some air trapped in that. But that also could be accomplished by the piping or valving arrangements of the fluid up to that, which I am not familiar with.

Q. Are you asserting that there is a cushioning effect present in the Crucible hold-down roll comparable to the cushioning effect that was present in the Montgomery low lift pinch roll position? A. I say it is possible to do so, if they so desired, yes.

* * *

[523] I will shift to Patent 065, which is at Tab 6 of the binder, Exhibit D-2. I want to ask you about a phrase in Claim 5 of that patent, line 51, starting really at 50, where it speaks of "feeding the thinned body to a reversing mill after cropping at least one end of the thinned body to facilitate its entry into said reversing mill." What is that

action that is referred to there? A. When the slab or the original body they are starting to roll has been rolled down to a thin enough gauge that they want to send it down to the finishing mill, quite frequently the ends, or the nose on it are fishtailed, or split, or some [524] defect on it, and they like to crop off the ends, preferably both ends, so as to assist in the piece entering the mill, and then to the pinch rolls and entering into the coiler.

Q. That act of cropping, then, consists of merely operating a shear to cut off either or both ends of the strip, if they have been deformed sufficiently to lead the operator to think they might make trouble if they were continued, allowed to remain on the strip? A. It is generally a policy to cut them off at all times if they are so equipped to do so.

Q. You say that is the policy. Do you mean at the Crucible mill, or do you mean mills generally? A. Mills, generally, although I have seen it done at Crucible.

Q. What is the shear in the Montgomery patent? Is it labeled? A. Which patent is that, sir?

Q. This is 065 that we are talking about. I think I found it in the text, the shear is the thing marked 13. A. 13, I think, that is right.

Q. It says, page 1, column 2, line 6, "A slab shear 13 is positioned at a suitable distance ahead of the mill 11 with a connecting roll table 14 therebetween." Now, you say that this act of cropping by means of a shear is general practice in rolling mills generally? A. It is quite frequently used, yes.

[525] Q. Did the Butler mill that you referred to yesterday have a cropping shear? A. Where?

Q. Anywhere? A. They had to have a crop shear when they rolled the ingot to a slab and cropped the slab in that process.

Q. Did they have any cropping shear that operated on the slab or any thinner piece of material produced from the slab on the way down to the final hot roll gauge? A. I don't recall that they did.

Q. It would be surprising if they didn't, wouldn't it? A. Not necessarily.

Q. You must have seen how many continuous hot mills? A. Half a dozen, possibly.

Q. Did you ever see one that didn't have a cropping shear someplace in fairly near proximity to the beginning of the finishing part of the mill? A. No, it is my recollection it is a general, accepted, good practice.

Q. And has been for how many years? A. For quite a number of years.

* * *

Recross Examination by Mr. Walker:

[547] Q. You remember on redirect examination Mr. Webb asked you a question about the statement in the text at page 1, Column 2, line 60, or line 59, where Steckel said, "I provide a mill which is relatively simple and compact in construction employing preferably but a single reducing stand, although it may in certain instances be desirable to divide the work between two stands."

Do you have the patent in mind, and that statement about which you answered questions on redirect? A. I had no patents in mind, I was just giving my own interpretation to a question, but——

Q. Now, Mr. Webb asked you—unless my memory is playing tricks on me—if there was any teaching in this patent as to how the work would be divided between two stands if one decided to follow the suggestion made by Steckel in this passage that I have just read. Didn't you

have such a question asked you and didn't you give an answer that you didn't find any teaching as to where you would divide it? A. I didn't recall that a reference was made as to this particular patent. I was putting it in the wording as he read it to me with—the understanding was that—did that wording, as he read it to me, definitely specify as to how the work should be divided, and my answer was that I [548] had no knowledge, or wouldn't know what his intent was as to how to divide the work. That is all.

[549] Q. Now, doesn't this patent disclose an operation in which part of the rolling is done in the flat, without the use of the coiling furnaces? A. Yes, sir.

Q. And it discloses another kind of rolling which does involve the use of the coiling furnaces, right? A. That is right.

Q. And the deflectors are down when you want to do flat rolling, and they are up when you want to do coiling rolling, is that right? A. That is right.

Q. Now, to do coiling rolling you have to have rather unusual equipment in the form of coilers in furnaces, don't you? A. You do.

Q. To do flat rolling you don't need any such appurtenances, do you? A. No, sir.

Q. Wouldn't you think it logical for anyone who had decided to follow this suggestion of Steckel to divide the work between two stands to divide it in such a way that the coiling rolling would be done in the mill that had coilers, and that the flat rolling would be done on some other millstand that didn't have coilers? A. If you had a mill setup in front of you and was told to [550] operate it and one mill did not have coilers and the other one did, you certainly would have to divide your work so as to do the coiling on the mill that had the coilers.

Q. Suppose you didn't have anything but a single stand reversing mill with coilers and you decided to follow Steckel's suggestion that instead of doing the whole job on that mill you would divide the work between two stands. Wouldn't you think it would be logical to put in an additional mill that didn't have coilers and do the flat rolling on it and do the coiling rolling on the mill that had the coilers? A. I would.

Q. A perfectly logical, straightforward way of dividing the work between two stands, if you were going to follow the suggestion, right? Have you answered? A. No, I didn't hear any question.

Mr. Webb: I would like to have the question read. I don't think he realized there was a question, you dropped your voice so.

(Question read by the reporter.)

A. That certainly would be a good way to do it.

* * *

GEORGE SACHS (COLD METAL EXPERT).

[583] *Cross Examination by Mr. Walker*:

Q. I am going to put up here Exhibit D-1. Do you recognize the relationship that exists between that chart and the Steckel '214 patent? A. That's correct, yes.

Q. I would like to check with you to see to what [584] extent the functions you attributed to the pinch rolls of the original Crucible installation are performed by the pinch rolls of that patent.

The first function that you attributed to the pinch rolls of the original Crucible installation when in their pinch posi-

tion was to feed the strip into the mill. That function was performed in the Steckel '214 patent, wasn't it?

The Witness: Can you repeat the question?

(Question read.)

A. Yes.

Q. The second function of the pinch rolls in the pinch position in the Crucible original installation that you spoke of was to pull the strip off the uncoiling reeler; that's right, isn't it? A. Yes.

Q. The pinch rolls of the Steckel '214 patent perform that function, don't they? A. Yes.

Q. Now, what additional function, if any, did the pinch rolls in the Crucible original installation perform when they were in the pinch position? A. Well, they performed that stopping function, too, and——

Q. All right. Let's speak of that. [585] A. And they also——

Q. Just a minute, doctor.

Mr. Webb: Let him finish.

Q. You have spoken of the stopping function. I want to discuss it. Don't the pinch rolls in the Steckel '214 patent perform that same stopping function that you attributed to the pinch position of the original Crucible installation? A. That's correct.

Q. Are there any other functions that the pinch rolls in the pinch position performed—— A. Yes, as far as——

Q. —in the original Crucible mill?

The Witness: Will you repeat the question?

The Court: You better wait till he finishes the question.

The Witness: Yes, sir.

(Question read.)

The Witness: Can you repeat that again?

(Question read.)

A. Well, I don't get that. We are talking about the Steckel patent '214 now, and there are, of course, other functions in the Steckel patent. Now you are switching your question completely to the Crucible mill now?

Q. I am not switching them at all. I have been [586] asking you right along about the functions performed by the pinch rolls in the Crucible mill, which was the first subject covered in your direct examination.

Now, you have listed three functions which they performed in the pinch position in the Crucible mill, original mill. Are there any other functions that you haven't mentioned yet? A. Well, I can't follow you, Mr. Walker. You asked me which additional functions the pinch roll performs in the Steckel patent. Now, I have never answered that question to its end.

Q. I have not asked you that. I have asked you if there are any functions performed by the pinch rolls of the original Crucible mill other than the three functions you have already listed in that connection? A. Well, now, coming to the Crucible mill—of course, I said already I have never seen the Crucible mill in operation in its original setup, so in that sense I can't answer your question. But from the drawings, and from whatever I can see, the original Crucible mill performs—would perform these same three functions in exactly the same way, by substantially the same means, and with the same effect or result as the modified installation does.

* * *

[621] Q. Now, as of May 25, 1955, you have had no experience whatever with reversing hot mills; that is right, isn't it? A. Prior to May, 1955?

The Court: You had no reversing hot mill experience?

The Witness: No practical experience, that is correct, yes.

Q. Well, had you had any impractical experience? A. Well, I have been engaged in the McLouth case as an expert and made a study, and of course studied on paper the operation of the McLouth mill in very considerable detail.

* * *

WILLIAM H. COLVIN (CRUCIBLE'S PRESIDENT 1945-1954).

[637] *Direct Examination by Mr. Walker*:

Q. Did you give consideration, along with the other management personnel of Crucible, to the installation of any other type of mill than the reversing hot strip mill that was put in? A. Yes, sir; there is—shall I answer? I thought I heard an interruption.

Q. Well, you did give consideration to another type? A. Yes, sir.

Q. What type was that? A. There are two types; one is a straight continuous mill, continuous in the breakdown and continuous in the finish, and another is a reversing breakdown and continuous in the finish.

Q. Were you personally familiar to any extent with the type of mill that you have referred to as a continuous mill? A. Yes, sir.

[638] Q. What mills of that type were you aware of? A. The first that was ever built, at Butler, Pennsylvania.

The people who organized Rotary Electric Steel Company in Detroit were the creators of that mill. That's Naugle & Townsend.

Q. You were familiar then with that particular mill, were you? A. Through them; yes, sir.

Q. Have you seen any other continuous mills? A. Yes, sir.

Q. You might mention a few that come to mind. A. The first mill installed at Great Lakes was in existence when I moved to Detroit, and the mill at Weirton was functioning.

Q. Will you describe very briefly what the rolling process was that was practiced in those continuous mills? A. Yes, sir; they both dealt only in carbon steels. The mill at Great Lakes and the mill at Weirton were both continuous in the breakdown as well as continuous in the finishing.

Q. Were they continuous between the breakdown and the finishing stage? A. There was a substantial gap between the end of the roughing train and the beginning of the finishing train.

Q. They were arranged in line with one another, [639] were they? A. Throughout the mill; yes, sir.

* * *

[642] Q. And when you reached the decision to put in a reversing hot coiling strip mill, did you give any consideration to the patent situation relating to such a mill? A. Oh, very definitely, yes. That came naturally because [643] of my friendship with Mr. McLouth, who had had difficulty with his patent situation up there of considerable magnitude.

Q. When you say difficulty I take it you refer to litigation? A. Yes, sir.

Q. With Cold Metal? A. That is difficulty to me.

Q. You reached a conclusion, I take it, to take a license from Cold Metal, is that right? A. Yes, for two reasons we reached that.

* * *

[645] Q. Did you ever know a man named Robert M. Keeney of Midland, Pennsylvania? A. I knew of him. He died before I came.

Q. You knew him? A. Yes.

Q. Who was he? A. He was ultimately president of the Pittsburgh Crucible Company, a wholly-owned subsidiary, operating in Midland, Pennsylvania.

Q. Did you know a man named John F. Ferm? A. Very well. He was our chief engineer while I was with the company at Midland.

Q. You signed on behalf of Crucible Steel Company of America the license agreement between that company and Cold Metal which was entered into on September 30, 1946? A. I will have to ask you to look and see. I probably did.

> Mr. Webb: We will agree that Mr. Colvin is the one who signed it. It is this Mr. Colvin.
>
> The Witness: If it says W. H. Colvin, Jr., that's I.

Q. Section 11 of this agreement says, "At any time after March 1, 1953, Crucible shall have the right to cancel [646] this agreement upon giving Cold Metal 30 days advance notice in writing of its intention to cancel."

Can you tell me in what manner the date, March 1, 1953, included in that section, was arrived at?

* * *

[648] The Court: Do you know of your own knowledge, sir, how you arrived at that date?

The Witness: I know from the reports read to me by our general counsel, who negotiated with Mr. Webb.

The Court: Well, I am sure Mr. Webb will verify them, if your counsel gave you the correct information, and if he didn't I am sure Mr. Webb will correct him.

So what did your general counsel tell you how you agreed on that date?

The Witness: I have to start before that. The [649] general counsel was instructed, in so far as he was able, to give a cancellation privilege to Crucible to cancel the agreement at the expiration of the Keeney & Ferm patent. Patent counsel for Crucible advised me that that was an incorrect request on my part, that the Keeney & Ferm and the Steckel patents should be regarded by me as essentially one.

Q. That is the Steckel '214? A. It is the one that expired slightly after the Keeney & Ferm. I then amended my request to our people and asked that we arrive at a cancellation date with the expiration of the Steckel '214. The negotiations resulted in a cancellation 18 months hence, and we accepted that. We accepted that on the assurance of our people that by establishing a mill that came within the Keeney-Ferm and the Steckel we would get a type of product such as we sought at a cost which we would make a living out of and get our money back and have a commercial operation.

Q. Now, did you have in mind, Mr. Colvin, at the time that license agreement was entered into, that upon the

expiration of those two patents Crucible would at least explore the situation as to the patents that remained alive and determine whether or not it would be necessary to continue using the subject matter of any of those patents?

Mr. Webb: Objected to as leading, your Honor, grossly leading, and as immaterial and irrelevant.

* * *

[650] The Court: Well, I got an idea that may save a lot of time. Suppose I now, as a juror, tell you that I have been disabused that they had any sinister motive in selecting a certain date or in doing certain things to modify their mill. [651] Let's proceed on what actually happened.

* * *

Cross Examination by Mr. Webb:

[664] Q. This small reversing hot mill has admirably served the purposes of Crucible since it was put in, has it not, in so far as supplying to Crucible hot roll strip for its agricultural department and for its cold rolling department? A. It has supplied it as well as a compromise mill could, and we have not been disappointed in the mill, if that is what you mean.

[665] Q. Yes. A. You understand this hot roll product is not merchandisable in its as rolled condition, generally.

Q. The product of this hot mill is not merchandisable? A. Not for many applications requiring great accuracy or fine finish.

Q. But as a matter of fact the product of the McLouth mill was sold, was it not? A. Yes, sir.

Q. And the product of the second McLouth mill was sold, was it not? A. I couldn't answer you about the second because I had nothing to do with it, I was gone from

Detroit by that time. The first mill, we were large consumers of that, and I know that they had to install cold roll equipment in order to use a substantial part of the production which they could not sell.

Q. All you are saying is that there are many applications where the fine finish and excellent surface of the cold reduced product is required as distinguished from the type of surface that you get from a hot rolling operation? A. No, sir, I am not saying that. I am saying that the finer type of finish and more accuracy end to end, which comes off a continuous hot mill in hot form, is superior to the product which we get off our mill, and we knew that when we built the mill.

* * *

WILLIAM BRUCE LOCKWOOD (COLD METAL'S PRESIDENT) RECALLED

[688] *Direct Examination by Mr. Walker:*

Q. The reversing hot mills sponsored by your company have been generally known in the industry as Steckel reversing hot mills, have they not? A. Yes.

* * *

LEROY VALETTE (CRUCIBLE'S ROLLING MILL SUPERINTENDENT 1947-1951)

[698] *Direct Examination by Mr. Walker:*

Q. Mr. Valette, were you at one time employed by Crucible in connection with its reversing hot strip mill? A. Yes, sir.

Q. What position did you hold in that company? A. Well, I started as superintendent of what was originally

known as the Universal plate mill and later became division superintendent, which covered the hot rolling operations and the cold reducing and finishing operations.

[699] Q. Was that the same position that Mr. Barnes, who testified here earlier, held? A. Yes, that he has now.

Q. Mr. Barnes succeeded you as division superintendent? A. That's correct.

Q. In charge of the Crucible hot mill and cold mill? A. That's correct.

* * *

[700] Q. So that you were Division Superintendent of Crucible at the time the various changes were made in the hot strip mill that have been testified about here? A. That is right.

* * *

[722] Q. Are the pinch rolls of the Crucible mill actuated automatically, as one of plaintiff's witnesses said? A. Automatically?

Q. Yes. [723] A. As to their respective positions, pinch up or down?

Q. Yes, sir. A. No, sir.

Q. How are they operated? A. Manually.

Q. Is the deflector roll of the Crucible mill driven at the time the entering end of the strip passes that roll on its way into the coiler—— A. No, sir.

Q. —as Dr. Sachs said yesterday? A. On our modified installation?

Q. That's right. A. No, sir.

* * *

[731] Q. Now, as of January, 1932, Mr. Valette, was it usual or unusual to have a roughing mill in line with a

finishing mill with a roll table connecting the two? A. That was usual.

Q. Is the Cushwa patent an example of a roughing mill in line with a finishing mill? [732] A. It is.

Q. What is the operation of this mill shown in the Cushwa patent on this chart? A. Well, it shows heating furnaces for heating a slab, it shows a mill, marked 5, for the purpose of reducing that slab, and in the specifications they cite reducing it into the neighborhood of a half inch or less.

Q. In that particular mill stand, No. 5. A. Yes. And since it is a slab, it is reduced a—I mean, there are a number of passes taken in that mill to reduce it, since it couldn't be reduced in one pass from the slab. There is a holding furnace that Cushwa provides for the purpose of placing the reduced plate, in the event there is something that prevents it continuing on its normal course. There is a shear 17 for cutting off the ragged end of the breakdown. And then there is a series of six stands which provide six passes for the operation of reducing it from the breakdown to the desired gauge.

Q. Now, do you see any difference in principle between putting a roughing mill in line with a finishing mill, which is a reversing finishing mill, and this Cushwa arrangement of a roughing mill in line with a finishing mill, which happens to be a continuous finishing mill? [733] A. No, I don't. Both roughing mills serve to accomplish the same thing, and that is reduce the starting slab to a point that the balance can be finished in the finishing stand.

[734] Q. Is the finishing operation in the arrangement of the Cushwa mill conducted at the same heat, or without reheating in the sense in which you understand that term to be used in the Montgomery Patent '065? A. Yes.

Q. Is there anything unusual about having a cropping shear as a part of a mill comprising a roughing part and a finishing part? A. No.

Q. It was suggested yesterday by Mr. Wilson that the shear 17 of Cushwa could be used only to crop the leading end of the material as it entered the finishing mill and could not be used to crop the trailing end. What is the fact about that? A. Well, that would depend on the location of the shear, or whether the shear could cut well when the material is moving. I don't recall anything in the Cushwa patent that places that shear in a position to limit it to one end or the other.

Q. Would you look now at the middle panel relating to the Keeney patent, and tell me, what is the relationship between the mill arrangement shown on this panel and the finishing mill of the Crucible hot strip mill? A. When you say the relationship, I am not sure I understand you, Mr. Walker.

Q. I want to know, do you think the finishing part of [735] the Crucible hot strip mill is the same in principle as this apparatus shown by Keeney & Ferm, or whether you think it is different in principle? A. The principle of Keeney & Ferm and the Crucible operation are alike. The difference in Keeney & Ferm over Crucible is the manner in which they locate some of the appurtenances, the manner in which they lead the material into and from the coilers, the manner in which they divert the steel; but the process of reducing a breakdown to finished product discloses the same principle.

Q. Now, when you are making that answer with respect to the Crucible finishing mill, are you making any distinction for present purposes between the original installation and the modified installation? A. No.

Q. Both the original and modified installation, in your view, are the same in principle but different in detail from that in the Keeney patent? A. Detail is the only difference in the two.

* * *

[736] Q. Does this Keeney & Ferm patent have provision for rolling in the flat through this 4-high mill shown here? A. Yes.

Q. And when that is done how does the strip get through? Is something movable there? A. Yes. Let's see if I can find the right identification of parts. Adjacent each side of the 4-high mill and what Mr. Keeney termed the chutes are movable parts. As the drawing shows, one end of it is at the plane of the table and the other end is in a position to feed in the pinch roll. To roll without using the coilers, it was his suggestion that those be raised, the end closest the mill be raised so that they would lie clear of the table and not interfere with any rolling in the flat.

Q. Then when one reached a thinness such that he wished to coil it, what would he do? A. He would drop the chute to the plane of the table so that when the material emerged from the mill, instead of following the table 3 it would be diverted up the incline through the pinch rolls and then on into the coiler.

Q. Now, let's talk about the shears. Where are the cropping shears in this patent? A. The shears are noted as item 68, one on the mill side of each pinch roll stand.

[737] Q. Now, a point was made here the other day to the effect that those cropping shears wouldn't be much use because they couldn't be operated while the strip—the mill would have to be stopped in order to operate them, I think that was the point. What is the fact about that? A. Well, the Keeney-Ferm patent discloses that the material

would be on the reels with the trailing end between the pinch roll and the millstand itself.

Q. Yes? A. (Continuing) In the right-hand view the dotted line that shows that first chute, shows that in a position to drop a crop on the table. Now, if that were in reverse, in other words, if the material was in the mill and the crop shear was brought into effect, the front end would be in the pinch roll, or somewhere beyond that. So the material being wound on the reel, the trailing end between the pinch roll and the mill, the natural thing to do is to shear it and the resulting crop dropped to the table for disposal.

Q. Where is the roughing operation conducted in the Keeney & Ferm arrangement? A. Keeney & Ferm speaks of another stand. He doesn't show it in a drawing.

Q. Will you refer to that part of the text beginning in the paragraph at the lower right of this chart, "In operation, assuming that the table 3 at the right-hand side [738] of Fig. 1 leads from the roughing mill, the roughed-down strip will be carried on this table into and through the initial pass between the reducing rolls 1." Is it your understanding that the Keeney & Ferm means by that there is a roughing mill over to the right here somewhere from which a roughed down piece of material comes from right to left to the finishing mill? A. That is right.

Q. What, then, does Montgomery Patent '065 show over and above what Keeney & Ferm shows? A. I can find no distinction between the two. Montgomery '065 teaches or discloses a way of reducing the material in a roughing stand, advancing it to, that is, to a point where the finishing stand has only the finishing to do. In other words, he is dividing the work between two mills, half of it, or essentially half of it, being done in a roughing mill, the other half being done in the finishing mill.

Q. At what stage in the reduction does the occasion to crop the ends arise? A. The cropping of ends on a mill of this type is to forestall any problem when the material becomes very thin. An irregular end can elongate to two, three, four, five, six feet, in some cases, and since there is a limit as to how much you can feed into the coiler, it is advisable to crop the breakdown so that there is no way, or so that there is no [739] chance of having an exaggerated, distorted end to feed into the coiler. You are so close to being finished that at the time it is important that you insure that every pass will engage the coiler as it should.

Q. If a strip which has been roughed down by the mill to the right of the figure in the Keeney & Ferm patent comes into the finishing mill and up into the coiler on the lefthand side, would it be in condition to enter that coiler without having the front end cropped if the roughing operation was properly conducted? A. In the heavier gauges it is unlikely that there would be an ear, as we call it, or a fishtail, long enough in that thickness to prevent the coiler from picking it up properly.

Q. Would you consider that there would be likely to be any occasion to operate the shear on the trailing end, that is, the shear 68 at the left, on that first pass? A. No.

Q. What would be the operation as it continued from that point on? A. Keeney & Ferm, as I see it, provides a shear on each side of the mill so that either the head end or the trailing end, or both ends, can be sheared at any time during the finishing operation that the operator feels it should be done. In other words, he can elect to shear the trailing end on the first pass into the first coiler, but if it is not [740] necessary at that time he need not shear. By the same token, on the first pass into the opposite coiler, he has the option of shearing, or not shearing on the first pass.

He can delay it to any point where he thinks it might create some trouble.

Q. Or he can omit shearing altogether—— A. Or he can omit shearing altogether.

Q. —if the condition of the strip is such as to not require shearing? A. That is right.

Q. In your mill, Crucible mill, to what extent is this cropping indulged in? A. Well, we have one shear that is used for shearing our slabs, that is, the crop ends from the slabs when we make ingots, we have the shear for shearing the reduced ingot into a multiple number of slabs, and we use the shear to crop both ends of the breakdown that is going to be rolled in the 4-high reversing mill. We shear both ends for the simple reason that once we start the coiling operation it is too late to decide whether we should go back to that shear and shear it or not.

In the operation of flats, where ears or fishtails are of not too much importance, it is rare that we will shear the crop end at all.

Q. Where you have a thing that is going to be coiled [741] and you do crop, is it the purpose of cropping to help the material enter the bite of the rolling mill rolls, or to help it enter the coiler? A. The coiler.

Q. Did you consider that there was anything unusual as of January, 1932 to include a cropping shear in a mill having a finishing mill and a roughing mill, like Montgomery '065? A. No.

Mr. Walker: Yesterday, your Honor, I asked Mr. Lockwood if he agreed that the Keeney & Ferm patent had given the world a new tool and a new mode of operation; he said he didn't know. Then I tried to read that statement into the record from a brief. I didn't happen to have Mr. Webb's brief,

but I had that quotation from it in my brief. He got up and said I couldn't read it from my brief because he couldn't find it in his brief. Well, I had better luck.

In Mr. Webb's main brief for Cold Metal Products Company in the McLouth against Cold Metal, the presently pending case, page 142, he said this, one short paragraph—one sentence: "Surely a reference such as this '670 patent—" that is that original Steckel patent with the coilers but no pinch rolls—"whose teaching is inoperative and impractical, and which does not disclose many important elements and [742] features of the Keeney & Ferm patent, warrants litle or no consideration when used in an effort to invalidate a patent of the character of the Keeney & Ferm patent, which has given the world a new tool and a new mode of operation."

* * *

Q. Will you look at the fourth panel of this chart, D-7, which is directed to Steckel Patent '214, and tell me whether or not that reversing mill has provision for rolling both in the flat and in coilers in furnaces on each side of the mill? A. Yes, this discloses the fact that at the option of a mill builder that he can design this mill for the work to be done in one mill, or he can divide it between two mills, meaning roughing in one mill and finishing in the mill described by Steckel '214.

Q. You have in mind there the first paragraph of the text at the bottom which says, "I provide a mill which is relatively simple and compact in construction, employing preferably but a single reducing stand, although it may in certain instances be desirable to divide the work between

[743] two stands"? A. That is what I was referring to, yes.

Q. If that latter suggestion of having two stands were employed, what would be involved? A. Well, the situation would then become similar to that that Crucible has in its present installation, a stand somewhere in line ahead of the mill described in '214 that is capable of reducing a slab to a breakdown and then finishing that operation in a mill described by '214.

> Mr. Walker: I think it is pertinent at this point, your Honor, to give your Honor the praise that was heaped on this Steckel patent by its owner in the McLouth case, where this patent was charged to be infringed by the mill, instead of being an expired patent in the prior art. That is on page 30 of Cold Metal's brief in that case, and under the heading Steckel Patent '214 it says: "This patent, Exhibit PX-2, issued on an application filed May 4, 1931. It discloses the original mill built and operated at Youngstown's Briar Hill plant. It was the mill of this patent on which Cold Metal," and now it is italicized, "for the first time in the history of the world," italics ended "demonstrated the commercial practicability of hot rolling strip on a reversing hot mill, with coiler furnaces on opposite sides of the roll stand."
>
> * * *

[744] Q. I am going back to the first panel, Montgomery '065, the very last part of the text that is reproduced there, where it says, "This means, however, that the finishing mill can operate at maximum efficiency at all times, being confined exclusively to high speed rolling with coil-

ing between passes and not periodically converted from a high speed strip mill"—it says metal, but obviously means mill—"to a slow speed slabbing mill in accordance with the disclosure of the Steckel patent." That being Steckel Patent '214 that we were just talking about.

Now, is the finishing stand of the present Crucible mill confined exclusively to rolling with coiling between passes? A. No.

Q. What other kind of rolling is conducted on that [745] finishing mill? A. The Crucible mill, from the moment that I can remember starting the mill, has always taken at least one flat pass in the finishing stand.

* * *

Q. I would like to have you now look at Exhibit D-8 for identification, which is a similar collection of panels.

Mr. Walker: This, your Honor, is intended to present the case as we see it on Montgomery Patent '122, Claim 10, which is a claim directed to the control of the side guides. The individual panels of this chart were prepared in the same manner that I described previously, taken photographically from the patents referred to, underlining the things that we think are significant. That is true of the two left-hand panels; the two right-hand panels are reproductions of defendant's drawings which were received in evidence this morning.

Here again the patent in suit is at the left, the accused device is at the right, and in between is mounted what [746] we consider an obstacle to the application of the patent in suit to the accused device, whether it be by way of invalidity or showing limitations.

Q. Would you explain the operation of the side guides in this Steckel Patent '214? What are the side guides in the first place? A. Well, the side guides are numbered 109.

Q. They are shown parallel to each other—— A. They are shown parallel to each other.

Q. —near the ends of the rolls of the roll table? A. I didn't hear your last remark, Mr. Walker.

Q. They are shown parallel to each other near the ends of the rolls of the roll table? A. That is right.

Q. How are they supported? A. Well, the guide of '214 shows a mechanism of two parallel guides with linking arms resting on the roll table, so that when the roll tables are operated in one direction the guide automatically takes either an in or out position; rotating the rolls in the opposite direction the guide takes a completely opposite position, whether it is in or out.

Q. What is it that causes the guides to move in? A. The movement of the roll table.

Q. Which moves the side guard itself longitudinally and then this toggle mounting is such that that longitudinal [747] movement brings it in toward the center of the pass line? A. Yes. He discloses when operating the tables to convey material toward the mill, the guides function to come in to the edge of the material and on reversal of the mill and tables—on the opposite side of the mill the guides are so linked to come out, so that they are away from the material. When reversing, each set of guides takes an opposite position, that is, close together or strip width, going in and out to their outmost limits on the delivery side.

Q. How does that action, that is to say, having the guides closer together on the entry side and further apart on the delivery side compare with the operation of the side guides in Montgomery Patent '122? A. Well, they are

similar in action in that the guides on '122 are brought together on the entry side when the mill and its tables are moved to operate, for example, to the right, the guides to the left then will be in a position at strip width. On the opposite side of the mill, instead of the whole guide moving out to give clearance to the issuing material, he discloses a method of opening the guides at the mill end of the guide so that they provide a space for the material to issue without obstruction.

Q. That is to say Montgomery on the delivery side opens only the mill end of the side guide to create what he calls a converging throat between the guides on the delivery [748] side? A. That is right.

Q. And these guides on the entry side are parallel, are they? A. That is right.

Q. Like the guides of Steckel '214? A. Right.

Q. And the guides on the entry side of both Steckel '214 and Montgomery '122 are closer together on the entry side? A. That is right.

Q. And further apart at the mill end, on the delivery side? A. That is right.

Q. Now, in the Montgomery patent what is it that the operator does to bring about the reversal of the positions of these side guides when the direction of rolling is to be changed? A. Montgomery discloses a method of tying into the main controller magnetically operated valves so that when the strip proceeds from left to right the pistons involved take the position to put the strip—the guides on the left side of the mill in a parallel relation and on the delivery side in a wide or converging position. At the same time the tables, the rolls and everything move with the movement of that controller.

[749] Q. What is it that the operator does to cause those guides to reverse their position when the direction of

travel of the strip is to be changed? A. He moves the controller to a running position.

Q. And it is that movement that controls not only the motor but the positions of the guides? A. Yes, sir.

Q. How does the operation in Steckel '214 compare with that? What is it that the operator does in '214 to change the position of the guides when the direction of travel is to be changed? A. Since the guide in '214 is moved by the table rolls, he must also move the controller to start the mill and table rolls in motion.

Q. Well, you started with the result and ended up with the cause. If the operator of '214—he has a motor control there, doesn't he? A. Right.

Q. And he has to move it one way to make the mill go that way and move it another way to make the mill go the other way? A. That is right.

Q. Having done that, moved that controller to dictate the operation of the mill motor in a particular direction, does he have to do anything else in '214 in order to cause the [750] side guides to bring themselves to the proper position? A. No.

Q. That happens automatically? A. Automatically.

Q. Now, in the case of the side guides of the Crucible accused mill, are those parallel guides on both the exit and delivery sides as in Steckel '214? A. They are.

Q. Are they close together on the entry side and wider apart on the delivery side, as in Steckel '214? A. They are.

Q. What is it in the operation of the Crucible side guides that causes them to reverse their position? A. The stopping of the mill.

Q. Will you elaborate on that a little bit, please? A. Well, at Crucible, at the finish of a pass when the trailing end of the strip is at the mill, or just discharged, the controller is thrown to off, or on the other operator's desk there is a stop button that stops the mill and coilers, tables.

Q. A stop button that a man hits with his hand, you mean? A. Touches. At the moment that this controller or stop button is moved to stop everything, the Crucible guides then function to reverse themselves preparatory to the next direction [751] of operation.

Q. Does the mill ever stop by reason of a circuit breaker going out through overload? A. It can.

Q. What happens to the side guards if that happens? A. They change position just as though it were stopped by a controller or stop button.

Q. Well, now, have you had any experience with side guides that were controlled or caused to be actuated by the motor controller, as in Montgomery '122? A. Yes. When we first put the side guides on what we call automatic at Crucible, which was several months after the starting of the mill, we used exactly that feature. In other words, when the operator moved the controller to move the mill table rolls and coilers in a given direction, the guides would then automatically start to position themselves for the position necessary for that pass. For example, left to right, the guides on the left side would be positioned then to be close to strip edge, those on the right side, or delivery side, would be positioned to give the strip clearance, which was approximately five inches wider.

Q. Did you find that to be a desirable way to operate as compared with the way you operate the side guides now? A. No, we didn't find it desirable. In fact, we only operated that way for several months.

[752] Q. What was undesirable about it? A. We found that the material could be into the mill before the guides had taken position, and if the strip was off the center, the guides would then tend to curl the edges in their attempt to reach their final position. In other words, they were too late in assuming the position that was required.

Q. Does it ever happen in your mill, as presently constructed, that the mill has been stopped in a normal way with the trailing end just past the mill rolls and then for some reason the operator wants to make it travel a little further in the same direction? A. Yes.

Q. When the operator moves his control in that situation, in such a way as to make the strip move further in the direction it last moved in, what does he find to be the case with respect to the side guides? A. The side guides are in the wrong position at that time.

Q. What does he do about it? A. He can use what we call the manual guide resetting button, by touching that they will automatically reverse themselves from whatever position they are in, or he can work the mill controller, just turn it on and set it off again to reverse the position in the opposite direction.

Q. That is to say, give it a double jog? A. Give it a double jog.

[753] Mr. Walker: I don't recall whether I offered Exhibit D-8 for identification in evidence; if not, I now offer it.

The Clerk: D-8, formerly marked for identification, now marked for evidence.

(Received in evidence as D-8.)

Mr. Walker: I now tender Exhibit D-9 for identification. This is four panels, the left-hand one is again Montgomery '122.

This chart is directed, your Honor, at the subject matter of the high lift-low lift of the pinch rolls, the subject matter of Claims 6, 18 and 19 of this patent. Here again the same procedure has been followed, the left-hand chart, Montgomery '122, the

next chart, Steckel '214 being derived solely photographically from the patents, and the two right-hand pictures are reproductions of defendant's drawings received in evidence this morning. Here again the patent in suit is at the left and the accused device at the right, and the obstacle construing the patent to be infringed by the Crucible mill is in the middle.

I offer this in evidence as Exhibit D-9.

The Clerk: D-9, formerly marked for identification, now marked for evidence.

(Received in evidence as D-9.)

Q. Before I forget it, on what date was the magnetic [754] drive installed on the deflector roll of the Crucible mill? A. November 19——

Q. I am very sorry. This being the high lift-low lift, what I want is the date on which the hold-down roll was installed. A. That was October 29, 1951.

Q. When the pinch rolls of the present Crucible installation are in the pinch position, do they perform any functions that weren't performed by the pinch rolls in Steckel '214?

* * *

[755] A. No, they are both for the same purpose.

Q. When the pinch roll of the Crucible installation is in its up position does it perform any function that was not performed by the pinch roll of Steckel patent '214 when it was in its up position? A. No.

Q. What is your understanding as to the mode of operation of the pinch rolls of Steckel patent '214 as described in the text of the patent, with respect to coiling rolling? A. '214 discloses that the pinch rolls would be used for

feeding the material from the reel to the mill and, as I recall, also from the mill to the coiler.

Q. Did the pinch rolls of Steckel '214 have any function to perform with respect to tension on the strip? A. Yes, '214 did disclose that the pinch rolls could be used for exerting a forward tension on the material as it issued from the mill and a retarding tension on the entry side.

Q. Was there anything about the construction of the mill of this Steckel patent to prevent the operator [756] from withdrawing the pinch roll from the strip by raising it after it had performed its function of feeding the strip into either the mill or into the coiler? A. No.

Mr. Walker: At this point I offer in evidence as Exhibit D-21 stipulation between the parties dated March 21.

* * *

[757] Mr. Walker: And the final paragraph stipulates that during a certain period plaintiff has title to all the patents in suit.

And in that connection, I note that the assignment to Cold Metal of the Keeney & Ferm patent, about which there has been so much discussion, does not appear on the face of the patent or in the file wrapper.

May it be stipulated, Mr. Webb, that the application for that patent was assigned to Cold Metal by Keeney & Ferm individually on November 22, 1928, and then on November 24, 1928, there was executed a sort of confirmatory assignment by Crucible itself?

Mr. Webb: I will stipulate that the application was assigned to Cold Metal Process Company by Keeney & Ferm in November of 1928 and that in that same year an assignment was executed by Cru-

cible. I don't understand what you mean by a confirmatory document, but does that take care of it?

Mr. Walker: Yes.

The Clerk: D-21, stipulation dated March 21, 1956, in evidence.

* * *

[758] Q. Do you have a copy of the Mohler article—
A. I believe I do.

Q. —which is included in this stipulation, Mr. Valette?
A. Yes, I do.

Mr. Walker: That is Item 3 of the stipulation, Exhibit D-21.

Q. Is there any disclosure there of the withdrawal of the upper pinch roll from the strip during coiling rolling?
A. Yes.

Q. What is the part you have in mind? I think you will find it on page 11 of this article from the Iron and Steel Engineer of January, 1933. A. Well, the bottom paragraph on page 11, for example, "The pinch roll on the leaving side is then lowered" which indicates that it has been in the up position.

Q. How about the fourth paragraph from the bottom of that column, which reads, "It might be mentioned that the pinch rolls are raised on the leaving side because they are only required for entering the piece into the main rolls"? A. That's right.

Q. Assuming that the operator of the mill, like that of this Steckel patent '214, raised the pinch rolls [759] after they had performed their function of feeding the strip into the mill, or into the coiler, as the case may be, a distance of three inches, then would you compare what the operation of that mill would be as compared with the

operation of the present Crucible installation? A. I would say they would be identical.

Q. Let's develop that in a little more detail. In passing from the mill rolls to the coiling reel the strip in the Crucible mill passes under the hold-down roll, and then under the deflector roll, on its way to the coiler? A. That is right.

Q. And in passing that same course, from the mill to the coiler, as Steckel '214 when operated as I described, it would again pass under the pinch roll in this case and the deflector roll on its way to the coiler? A. That is right.

Q. Are any of those rolls driven during the coiling operation? A. No.

Q. In either '214 or the Crucible? A. No.

Q. What functions are performed in the Crucible mill by the hold-down roll? A. The hold-down roll on the Crucible mill is provided [760] for one purpose, and that is to maintain the strip that is traveling from one coiler to the mill, or from the mill to the coiler, below the upper edges of the guide box so that at any time that the material would tend to move sideways toward the guide box you would have a long face to resist any tearing or such things that might occur.

I might give a little bit of a demonstration here. This will stand more resistance along this whole face of the bench, but by coming across the guide like this——

Q. At an angle. A. —it is very readily turned over. And that is the reason that we provide a hold down to firmly hold that into position, just above the mill table and below the tops of the guides.

Q. Now, you spoke of the guide box originally, now you are speaking of the tops of the guides. Would you explain in a little bit of detail what the form of those side guides is.

or what you mean by the guide box? A. Well, we call the guiding apparatus on each side of the mill the guides or the guide box, inasmuch as it has a boxing effect.

The Court: What figure are you look at?

Mr. Walker: Figure A-10?

The Witness: I was looking at three, but let's [761] look——

Q. Look at Figure A-10, if you will, of D-3.

It is a black binder that we put in this morning, your Honor. I think you have it.

The Court: D-1?

Mr. Walker: No, D-3.

The Court: Anything that shows what you are referring to.

A. The reason we sometimes term it a guide box, normally when you talk about guides only you are not talking about a lower or upper part. When we refer to a guide box normally it is because it has a lower, a side and an upper part, in other words, to form a box.

Now, this box does not extend, of course, the whole length of the guide. It starts the boxing in here and directs the material, should it be turned up, down to the bite of the roll. This is a straight guide. It has a lower flange, but it doesn't have the upper flange at this point. So to prevent the strip coming in at a high angle and cutting across the top of this, or interfering with this top part, is what we call the box. The purpose of it is to maintain that line as parallel, you might say, with the table itself.

The Court: The pass line.

The Witness: The pass line.

[762] Q. Not strictly parallel but nearly enough to parallel to not run into the top flange? A. That's right.

Q. Now, what is the function of the low lift position of the pinch roll in Montgomery patent '122? A. Well, Montgomery '122 provided the low lift position to relieve it from the pinch position.

Q. Is it your understanding from the drawings and text of Montgomery patent '122 that it is any part of the intention of that apparatus to have the pinch roll in contact with the strip when it is in the low lift position? A. According to Montgomery '122 he continually talks about lifting the pinch rolls off the strip, or from the strip, or some such thing as that.

Q. And if it is lifted off the strip then it doesn't perform any hold-down function, such as the hold-down roll of the Crucible mill performs, is that right? A. If it is lifted—of course, he doesn't specify a distance, so we don't know what he is talking about in distance. And his purpose seemed to be to provide a method to relieve the pinch, get the pinch roll away from the material.

Q. And if it is lifted off the material then it doesn't hold it down, does it? [763] A. No.

Q. Do you have any understanding of the purpose of providing that low lift position described here by Mr. Freed of relieving the mill from the strain of having the pinch roll drop from a fully elevated position down to the pinch position? A. It hasn't been a problem in our experience. We operate it that way now, from 12 inch to pinch position, every time we use it, which is at the beginning of each pass, or at the trailing end of each pass.

Q. So that if there is any advantage from that standpoint in having a low lift position you don't take advantage of it? A. That's right.

Q. Now, how about the cushioning effect that is provided for the pinch roll in its low lift position in Montgomery patent '122, do you have an understanding of what I mean by that? A. As I understand Montgomery '122, the two cylinders that raise the pinch roll from pinch position to high lift position have a feature whereby the air can be locked above the piston. In other words, to effect the low lift position in Montgomery, assuming the pinch roll is in pinch, then in operating the low lift cylinder the low lift cylinder overcomes the contained pressure within the [764] cylinders that do actually the raising of and that are connected with the pinch roll itself, which has room for some compression and, I am assuming, some floating, should there be a situation of it created.

Q. These are all air operated in the Montgomery '122? A. I can't recall from memory whether he is talking about both.

Q. At least the long stroke cylinders are air, aren't they, because those are the cylinders that act as cushions? A. That is right.

Q. Now, in the Crucible hold-down roll, that piston is actuated by hydraulic fluid rather than air? A. That is right.

Q. Is that design such as to give that hold-down roll any cushioning ability? A. No. In fact, the cushioning—as we all know, we originally operated the mill according to the high lift-low lift features of Montgomery. The cushioning we found undesirable, inasmuch as any change in—or any condition that would allow that roll to raise up and down didn't give us what we felt a stable operation, so in converting over to the so-called auxiliary or hold-down roll we purposely put hydraulic pressure and substatnially greater [765] pressure than that we used in the old setup with air, so that we would have a rigid holding roll. In fact,

it came down and actually pressed against stops on the housing.

Q. I now ask you to direct your attention to another chart, Exhibit D-10 for identification.

(Marked Exhibit D-10 for identification.)

Mr. Walker: This one is directed to Montgomery patent '107, with particular reference to Claim 6 of that patent, on the subject matter of tensioning the strip, your Honor.

This chart has five panels. The lefthand one relates to Montgomery '107, the next one to the right to Steckel '670, and the next one to the right to Keeney & Ferm, the next one to the right to Steckel '214, and, finally, on the fifth righthand panel, the Crucible accused mill.

Here again the patent in suit is separated from the accused structure by those patents which we consider interpose obstacles to the application of the patent to the mill. All of them are derived photographically from the patent stated.

I offer it in evidence.

The Court: It may be marked.

The Clerk: D-10, formerly marked for [766] identification, now marked in evidence.

(Received in evidence as D-10.)

Q. Now it becomes appropriate to ask you for the date on which the magnetic drive was installed on the deflector roll of the Crucible mill. A. I remember it as November 19. I will just verify it. That was November 19, 1951.

Q. What is the situation with respect to tension in the strip in the mill shown in Steckel patent '670? A. Steckel

'670 discloses that each motor—each coiler motor is driven and may be operated at such a rate to maintain the delivered strip under tension.

Q. Would the tension, if the mill were so operated, be uniform or non-uniform between the coiling reel and the mill? A. I would say it would be uniform since there is nothing between the mill and the coiler to interfere with the uniformity.

Q. If the uncoiling reel were so driven as to impose tension on the strip, is there anything there to interfere with uniformity of tension all the way from the uncoiler reel to the mill? A. No, there wouldn't be.

Q. What is the situation with respect to tension on the strip between the coiler reels of Keeney & Ferm and [767] the mill of Keeney & Ferm? A. Keeney & Ferm operates a little differently in that between the coiling reel and the mill, or the uncoiling reel and the mill, there is a set of pinch rolls and Ferm does not disclose a method by which the pinch rolls can be retracted. But he does disclose that once the material is in the mill, from the feeding side to the winding reel on the exit side, that he disconnects the drive from the pinch rolls and they act as idlers.

Q. Well, let's get first to the question of whether there is any tension or not in the strip. A. Yes, there is.

Q. What creates that tension? A. On the unwinding reel he suggests a drag brake, so that the unwinding reel will have a tendency to hold back between the reel and the mill.

Q. Now, what would create forward tension in this mill, tension on the delivery strip? A. The winding reel creates the tension between the mill and the reel, actuated by the operator. Ferm also provides, in the event the operator has not accurately adjusted his winding reel to the speed of the

mill, and creates a loop between the mill and the reel, a device which I guess you could call a looping arrangement, for taking up that slack and holding it under tension until [768] the operator actually brings the reel into the speed that he desires to have for the tension that he wants to wind.

Q. Is that thing you have just been describing what is referred to in the third paragraph of this panel of the chart reading, "Tension is maintained yieldingly upon the looped strip, as shown in Figure 1, by means of the fluid pressure cylinders, and the size of the loop aids the operator in adjusting the speed of the rotation of the reel in the coiler to the speed of the reducing rolls"? A. That's right.

Q. Are the pinch rolls of Keeney & Ferm used to feed the material into the coiler or the mill rolls, as the case may be? A. Yes, both.

Q. And after they have performed that function what happens to the drive in Keeney & Ferm pinch rolls? A. He discloses using magnetic clutches between the pinch rolls and the driving motor so that the pinch rolls would operate as idle rolls.

Q. And would the presence of those pinch rolls have any material effect, in your opinion, upon the uniformity of tension between the winding reel in the mill and between the mill and the unwinding reel? [769] A. As against Steckel—an arrangement such as Steckel '670, I would say yes. The winding reel is supplying the force, for example, for the tension, but between the winding reel and the mill there is a pair of idler driven rolls, which are being turned by the winding reel, or the movement of the strip, due to the winding reel.

Q. Let's examine Steckel patent '214, the fourth panel of this chart, and consider that mill with its pinch roll raised three inches, following the suggestion in the Mohler article that we spoke about a few minutes ago, and see what the

situation in that mill would be with respect to tension on the strip. Would there be any tension, in the first place?

The Witness: I would like to have the question repeated. It is quite long.

(Question read.)

A. Well, I would say yes, there would be tension, but it would be applying it different than the original Steckel '214 suggests, where he used the pinch rolls for exerting some of the tension.

Q. So if you raise the pinch rolls they could no longer exert that tension? A. That's right.

Q. Would the coiler reel impose tension, if it [770] was properly driven? A. The coiler reel would be the force to impose the tension.

Q. And what, if anything, would there be in that mill to interfere with uniformity of tension all the way between the coiler reel and the mill? A. It would be a situation similar to Steckel 214. There is a roll 99 in the furnace, which is an idler roll, or bottom side of the furnace, which the strip ends around, and the force of the reel is required to turn that roll. Then the roll 68——

Q. The Steckel pinch roll? A. That's the top pinch roll in Steckel '214. If it were in a position to engage the strip, then additional force would be required to turn that roll.

Q. How would that situation compare with the situation in the Crucible accused mill? A. Well, they would be, in my opinion, identical.

Q. In both cases the strip would be in contact with two rolls, both of which are undriven? A. Right.

Q. In its passage between the mill and the coiling reel? A. Right.

Q. Now, in what circumstances is your deflector [771] roll driven, and in what circumstances is it not driven, in the installation as operated since November 19, 1951? A. When the mill is not coiling material it is necessary to rotate the deflector roll and the coiler for the purpose of preventing warpage. And it is only at those times that there is a drive on that deflector roll.

Q. What does the operator do with respect to the drive, is it operator controlled or is it automatically controlled in some way? A. Well, bringing it into a driven roll, or removing it from a driven roll, the operator on his control—I would like to refer to a drawing here. I believe it is A-23—A-25.

The Court: The operator's panel.

The Witness: A-25 is the assistant operator's. So far as the function is concerned, they apply on either desk.

A. On that drawing is shown, in the first line of controllers—coiler No. 2 selector switch, which shows: jog, off, normal and idle. To begin coiling the operator throws the selector into the normal position. That disconnects the driving clutch that drives the furnace deflector roll. Jog position is the position which engages the clutch. So that at the beginning of an operation, when [772] they get ready to coil, this selector is put on the normal position, and it is left on that position throughout all the passes of coiling. So throughout all the passes and at all times during coiling the clutch to that roll is disconnected.

Q. So that when the entering end of a strip approaches the coiler furnace it finds that roll stationary? A. Not driven.

Q. And any rotation that the roll does from that time until coiling rolling is discontinued, and you go back to flat rolling, the power for turning it comes from the strip itself? A. That is right.

[773] Q. In the left-hand panel, Montgomery '107, we have included at the top of the third column Claim 4 of the patent, the last clause of which reads, "and driving said guide roll to prevent frictional drag on the breakdown." What is your understanding of the meaning of that phrase "prevent frictional drag on the breakdown" as applied to this Montgomery patent structure? A. Well, my understanding of that particular part is that it is his intention to drive that roll at the same speed that the material is moving, so that the material itself has no effect on the movement of the roll. In other words, to synchronize the two so that the strip is not forced in any way to make that roll revolve.

Q. And if one did drive that roll at a speed precisely synchronized with the speed of the strip, would it be true that that roll would then be eliminated as a cause of creating inequality of tension in strip one side of that roll against the other? A. In my opinion, yes.

Q. Is that in your opinion a factor of any commercial significance? A. I would say no.

Q. In any event, whether it is or not, you don't take advantage of that feature in your mill as operated since November 19—— [774] A. We do not.

Q. 1951? As a matter of fact, Mr. Valette, is it commercially feasible to synchronize a roll that closely, that its peripheral speed would be precisely that of the strip? A. I would say there are circuits or methods by which two rolls of that nature can be. I know that Crucible's electrical circuit does not provide for driving that particular roll at the precise same number of feet per minute as the strip. We

have conditions that will have some variation in that. For example, our mill roll diameters are 27¼ inches down to about 26 inches, and each time you change that while the motors are attempting to drive it the same, actually the peripheral speed of each of these rolls then becomes different.

Q. If there were no patent consideration involved, would you prefer to have your deflector roll in your Crucible mill driven by the strip or driven by a motor during the coiling operations? A. Actually, I don't see too much difference; one is that you don't have to maintain equipment, that we have to maintain now.

Q. Well, you are speaking of the magnetic clutch, the intermittent drive? A. Yes.

Q. I am asking you about having any drive at all during [775] the coiling operations as compared with having the kind of a drive that Montgomery '107 is talking about? A. The drive isn't essential in so far as rolling strip is concerned. If it wasn't for the fact that you must prevent it from idling, we would never put a drive on in the first place, of any kind.

Q. Do I understand correctly, then, that as long as you had some way of driving it when you are not coiling, then you are indifferent as to whether it has its own drive during the coiling operations or is driven by the strip? A. That's it exactly.

* * *

[776] Q. Mr. Valette, I would like to have you state what functions the hold-down roll in Crucible's present installation performs? A. The only reason for putting that hold-down roll into the mill is to hold the strip at about the pass line, so that it is contained within the guides.

Q. Now, in the Crucible installation, before the installation of that hold-down roll, was that function performed by the pinch roll in its low lift position? A. Yes, it was.

Q. Was that function performed by the pinch roll of the Montgomery patent in its low lift position? A. I would say yes. I mean, depending on where he calls low lift in his patent. He doesn't state what his elevation is.

Q. Well, if you honor the statement of the text that that pinch roll is lifted off the strip, then does that pinch roll in low lift position perform the function of holding down the strip? A. In that case, no.

Q. Now, Dr. Sachs attributed to the pinch rolls of the [777] Crucible mill in the low lift position a couple of additional functions. One of them was to prevent the sidewise movement of the strip. Do you agree with him that the pinch roll of the Crucible mill in the low lift position performed that function? A. No, I don't.

[778] Q. Is that function performed by the hold-down roll in the present installation? A. No, I don't.

The Court: You mean, no it is not?

The Witness: What I mean to say is that the hold-down roll does not have any tendency to guide the material laterally, whether it is the pinch roll or the hold-down roll.

Q. Another function that Dr. Sachs attributed to the Crucible mill in its low lift position was something to do with the prevention of looping. What can you say about that? A. The hold-down roll cannot——

Q. No, I asked if the pinch roll in its low lift position—— A. The pinch roll cannot prevent looping in the low lift position for the simple reason that looping isn't a function of the pinch roll in the low lift position.

The Court: Wait, wait, let's have that answer again.

(Answer read by the reporter.)

The Court: No, I don't think he means that.

Mr. Walker: I don't even understand it.

The Court: No, I don't, either..

The Witness: Well, when you say does it prevent looping—as I understand the question, you said does it prevent looping.

[779] Q. Yes. What is your statement about it? A. Well, essentially what I said before.

The Court: Is that the function?

Q. Let me try it again. A. What I am trying to say is that the pinch roll in the low lift position is in a position so whether there is looping or whether is not looping it is going to be there. In other words, if the reel is not taking up the slack the pinch roll cannot change the fact that the loop is there.

Q. Now, do the pinch rolls of Steckel '214 have any effect in preventing looping? A. Well, the pinch rolls in '214, as disclosed, where they are driven, the situation is somewhat the same thing. If they are driven at the proper speed there is no looping; since they are in pinch position and there is looping, it means that the pinch roll isn't going fast enough to create the loop, so it is held between the pinch roll and the mill.

Q. If the pinch rolls in Steckel '214 were driven as the patent teaches, namely, in such a way as to impose tension on the strip, then would looping occur? A. Read that question again, please.

(Question read by the reporter.)

A. I still don't digest the question, will you try it again, please?

Q. Well, let's consider the delivery side of the Steckel [780] '214 mill. It is true, isn't it, that the Steckel patent teaches that the pinch roll on the delivery side shall be driven in such a way as to impose tension on the strip between the pinch roll and the mill? A. That is correct.

Q. And the strip will be held taut between the pinch roll and the mill? A. That is right.

Q. In those circumstances can it loop in that position? A. Not as long as it is driven to exert a forward tension it can't——

Q. All right. A. —form a loop.

Q. Now, on the entry side is it your understanding that the pinch roll on the entry side of the Steckel Patent '214 is also driven in such a way as to impose back tension on the strip? A. That is right, that is my understanding of the patent.

[781] Q. And if so driven, can the strip loop between the pinch roll and the mill? A. No.

Q. Now, let's consider that part of the strip between the pinch roll and the coiling reel. At what speed should the coiling reel be driven? A. It should be driven at the same speed or—let's start all over again. If you are winding the material on the reel, it should be driven at the exact same speed, or with a tendency to drive slightly faster.

Q. For what purpose? A. For the purpose of exerting tension.

Q. If tension is exerted that way, is the strip going to loop? A. It cannot loop.

Q. Now, the unwinding reel, at what speed is that supposed to be driven? A. The unwinding reel, the purpose of that is to do just the reverse. The intent is to drive the unwinding reel at a rate slightly less than the mill is receiving it, to exert a back tension or drag on it.

Q. And if the uncoiling reel is so driven, can looping occur between that unwinding reel and the pinch roll? A. No, it can't.

[782] Q. Do you consider it feasible to operate one of these reversing hot coiling mills without having tension on the strip, on both the delivered strip and the entering strip? A. I can't visualize it being operated at all, from our own experience.

Q. What has your experience ~~been in~~ that regard? A. That any time that there is a failure of tension on one reel or the other, as has been said by other witnesses, the material will flop from one side to the other; in other words, it will skid and do such things as that.

Q. Get into a sort of a mess? A. That's right. In other words, the steel is coming to the winding reel faster than it can take it, so it has no set place to go to. On the unwinding reel, the same thing will apply. If it is unwinding faster than the mill is receiving it, it takes the shape somewhat of a clock spring that has been let loose.

Q. Now is there any one of these patents that we've had under discussion here this morning that does make any provision for handling a loop in the strip if a loop should form? A. Keeney & Ferm has a device, in the event, starting a strip, the winding reel has not been synchronized to take [783] the strip as fast as it is coming from the mill, a device that will create a loop; in other words, to take up the excess number of feet between the mill and the reel.

Q. And that is the apparatus referred to—— A. That is the apparatus on our—I don't know what these exhibit numbers are.

Q. I can find it. It is on the middle panel of Exhibit D-10, the third paragraph, where it speaks of, "Tension is

maintained yieldingly upon the looped strip, as shown on Figure 1," where there is sort of a rack—— A. That's right.

Q. —that accommodates the loop, maintaining the tension. A. The devices he suggests on that same sheet are shown as Figures 5 and 6.

Q. Now, at record page 570 Dr. Sachs testified about still another function of the low lift position of the pinch rolls in the Crucible original mill where he said, at the middle of the page, "Now, the low lift position also has a certain function in tensioning the strip." Did the pinch roll position of the original Crucible mill have any such function as that? A. None to my knowledge.

Q. Does the low lift position of the Montgomery patent have that function? [784] A. None to my knowledge.

Q. Then the last one I can find, in the way of a claimed function for the low lift position of the pinch roll, is also at page 570 [App. 55a] of Dr. Sachs' position, where he says, "It keeps the strip away from the table rolls and the table aprons and thus eliminates some scratching of the strip. And since, of course, this is expensive material, like stainless steel, any damage to the surface of the material is a disadvantage."

Did the pinch roll of the Crucible mill in its low lift position have any function of keeping the strip away from the table roll? A. There is none—no such function. The tension applied for winding and unwinding is the function that keeps the material off of the table.

Q. And so long as the pinch roll is elevated off the strip, then it is immaterial, from the standpoint of getting the strip off the table, whether it be retracted to low lift or high lift, is that right? A. It doesn't make any difference. The higher it goes, the higher the strip will go off the table.

* * *

[791] *Cross Examination by Mr. Webb*:

Q. So that from a practical standpoint you found it desirable to go through the material in the flat on the first pass and then go into the coiler on the north side on the second pass? A. That's right.

Q. But you have operated the Crucible mill in such way as to go into the coiler on the first pass, have you not? A. I have never seen it successfully done, myself, Mr. Webb.

Q. It was operated that way at times while you were still there in charge of the operation of the mill, wasn't it? A. On the first pass I can't recall a time that we did it. As I said, when we first started the mill, knowing that this was the intent, we tried it and we didn't find any success or advantage in trying to coil on that first pass, and we dropped it as a procedure.

* * *

[803] Q. What do you mean by free scaling? A. Well, when you are talking about free scaling in the millman's terminology, you are talking about the formation of scale arising on the metal being reduced and then having a tendency to loosen up so that it can be removed.

Now, at Crucible we remove the free scale that arises from the time it leaves the 2-high roughing mill, just prior to entering the 4-high finishing mill.

Q. But when the material goes down the table to the finishing mill it is at a point where free scaling has substantially ceased, and, as I understand it, as you go into the finishing mill you take off that scale? A. The scale is forming at that time, Mr. Webb, as it progresses from one end to the other. And you understand, [804] we are cleaning scale all through the roughing operation by the same method, high pressure water.

Q. Yes. And, however, by the time you go down to the finishing mill the free scaling has stopped, has it not? A. I would say no.

* * *

[808] Q. Yes. Then the patent goes on and says, "The material enters the mill 15 while still hot and is coiled up in the coil-heating furnace after the first pass through the mill." Now, as I understand your testimony, Crucible has found it preferable from its operating standpoint to go through the mill without coiling on that first pass, and then to coil on the second pass? A. That is right, after the second pass.

[809] Q. Yes, as the material goes through the second pass the material is coiled on the north side, is that correct? A. That is right.

* * *

[917] *Redirect Examination by Mr. Walker*:

Q. Mr. Valette, I have already mentioned this cushioning business. What is the fact as to the nature of the hold-down given to the hold-down roll of the Crucible present installation by it fluid pressed piston? Is it a cushioning or isn't it? A. As I have said, the purpose for putting hydraulic fluid on that was to give us a firm position. When we had the air cushion the cylinder would move anywhere from a half inch to as much as a full top stroke of the cylinder. In other words, it could go ten—it could float eight or ten inches, which was an undesirable feature. We put hydraulic on so we could maintain a fixed point. Now, I did on cross-examination say there was some float, but it is in the [918] area, I would say, of at the most, ten per cent of what it formerly was.

EXHIBIT D-1, Fig. 1

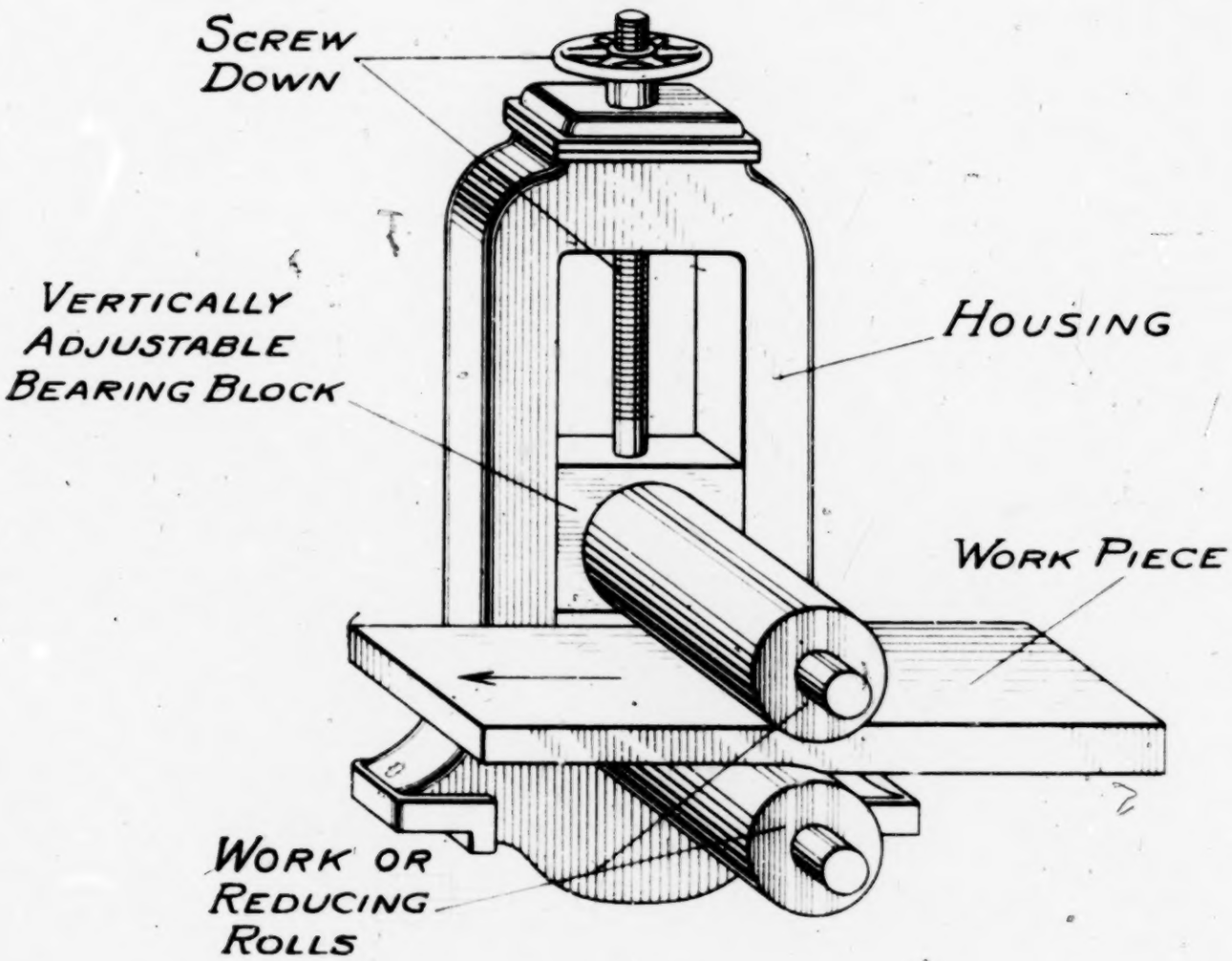


FIG. 1.
2-HIGH MILL

EXHIBIT D-1, Fig. 2

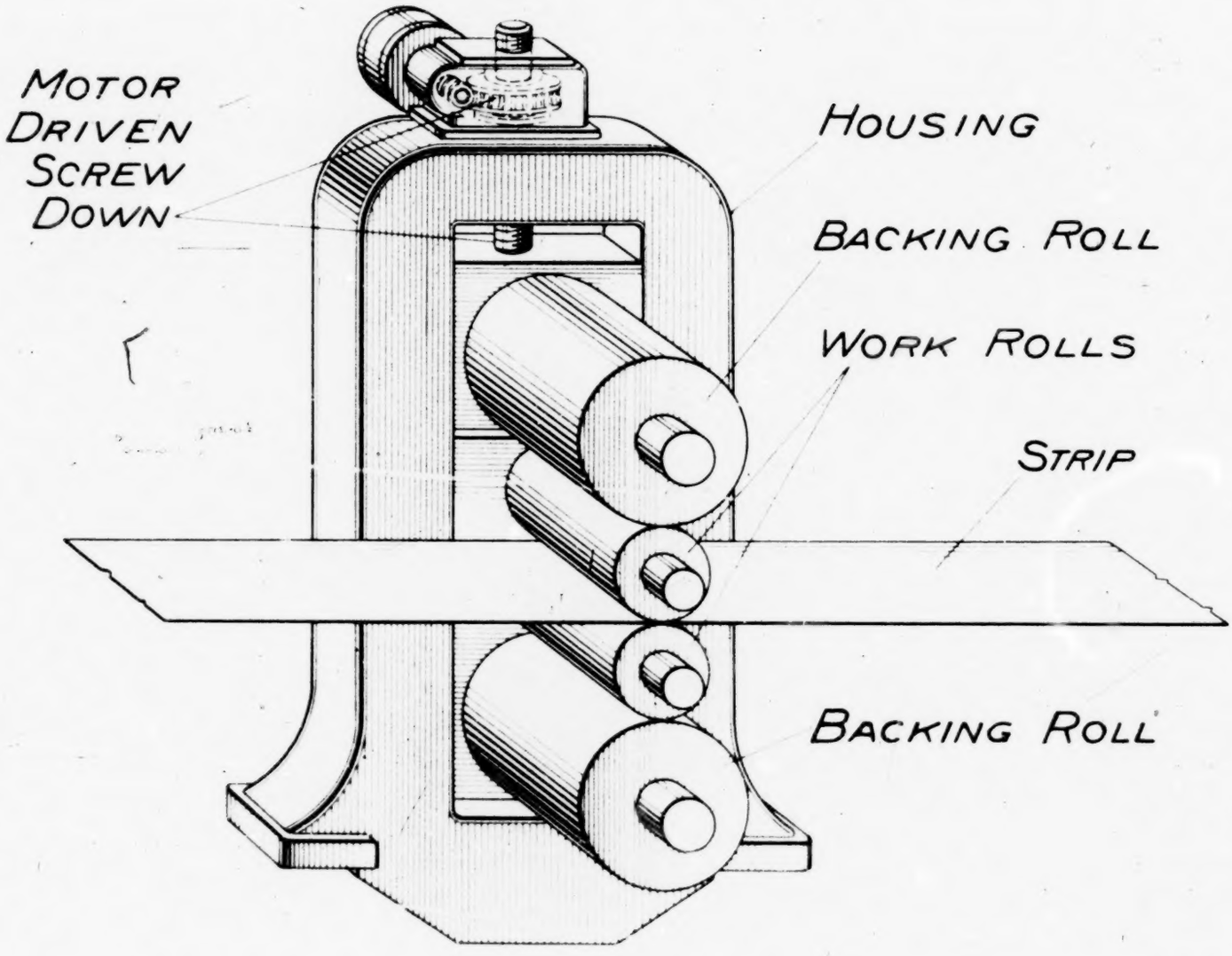
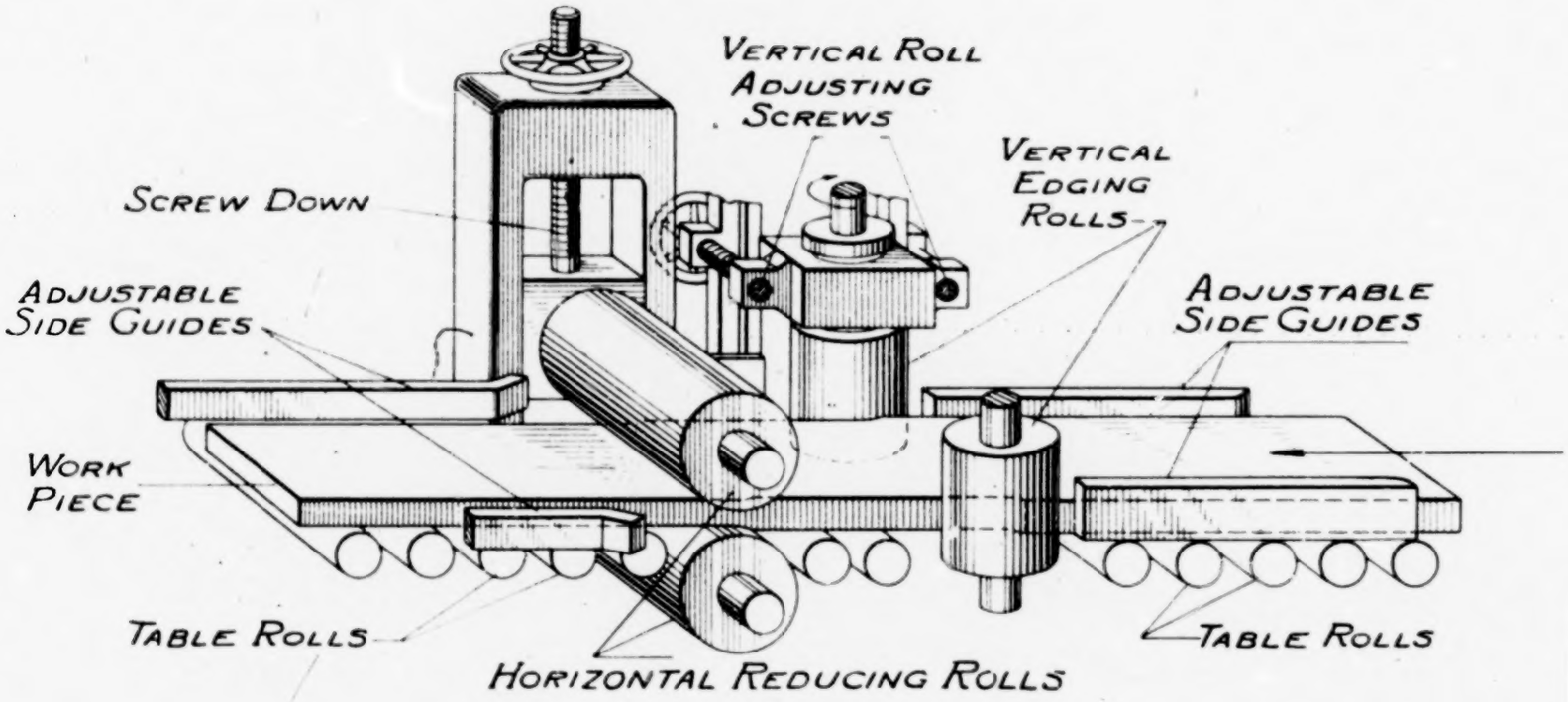


FIG. 2.
4-HIGH MILL

EXHIBIT D-1, Fig. 3



UNIVERSAL OR ROUGHING MILL

FIG. 3.
UNIVERSAL OR ROUGHING MILL

Q. You mentioned two or three-thousandths, I think, on your cross-examination—two or three-thousandths of an inch of variation of position; is that what you meant? Did you say two or three-thousandths? A. I don't recall exactly the figure that I talked about. The object was to hold it firm.

Q. As firmly as is mechanically possible? A. That is right.

Mr. Webb: Let's let the witness testify, please, Mr. Walker. There are reasons why I didn't stipulate on that printed description, as I have already said, and I don't think that it is necessary for you to testify on these points where there are contradictions. Let's get some testimony.

The Court: Well, the object is to hold it firm, then, is that right?

The Witness: That is exactly it, your Honor.

The Court: And generally speaking it is held firmly?

The Witness: Yes.

* * *

EXHIBIT D-1, Fig. 4

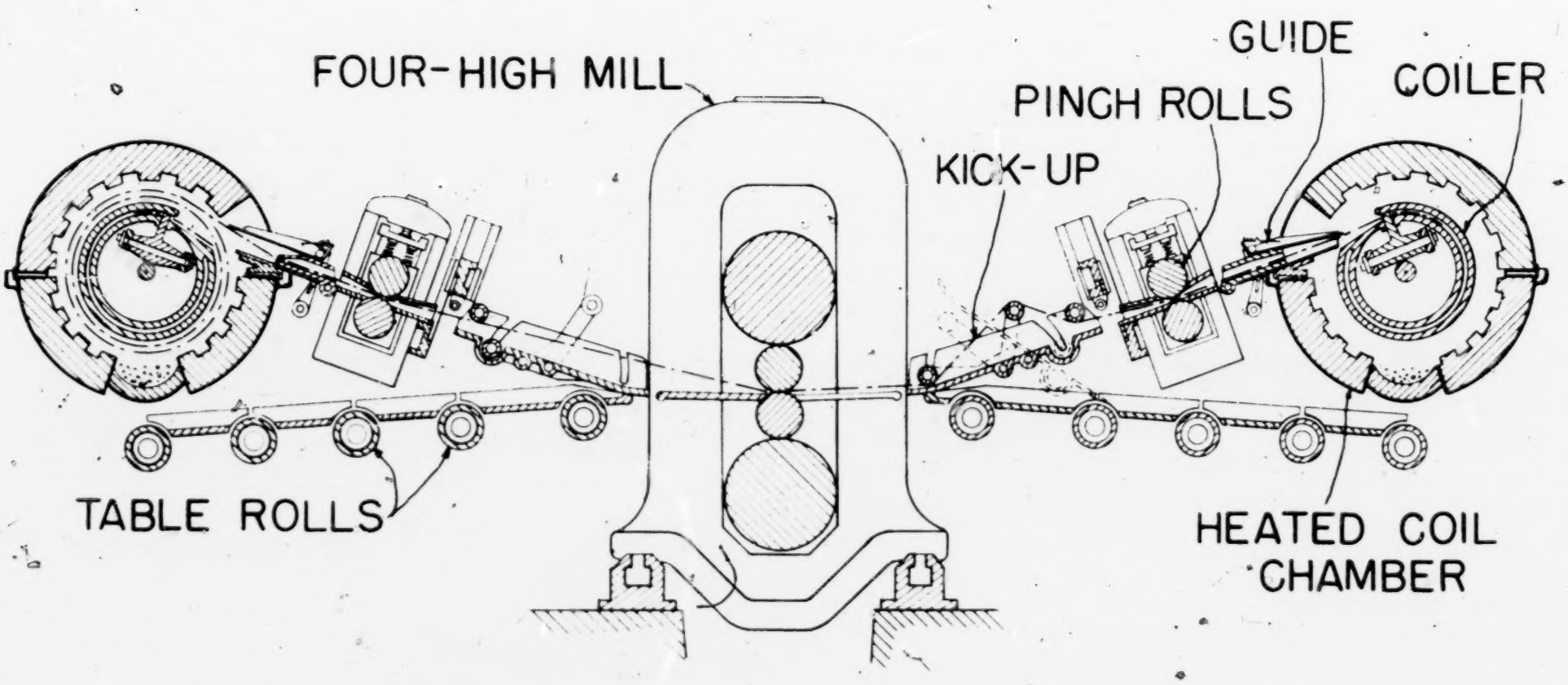


FIG. 4.

THE KEENEY & FERM MILL (ADAPTED FROM FIG 1 OF KEENEY & FERM PATENT NO. 1.918.968).

EXHIBIT D-1, Fig. 5

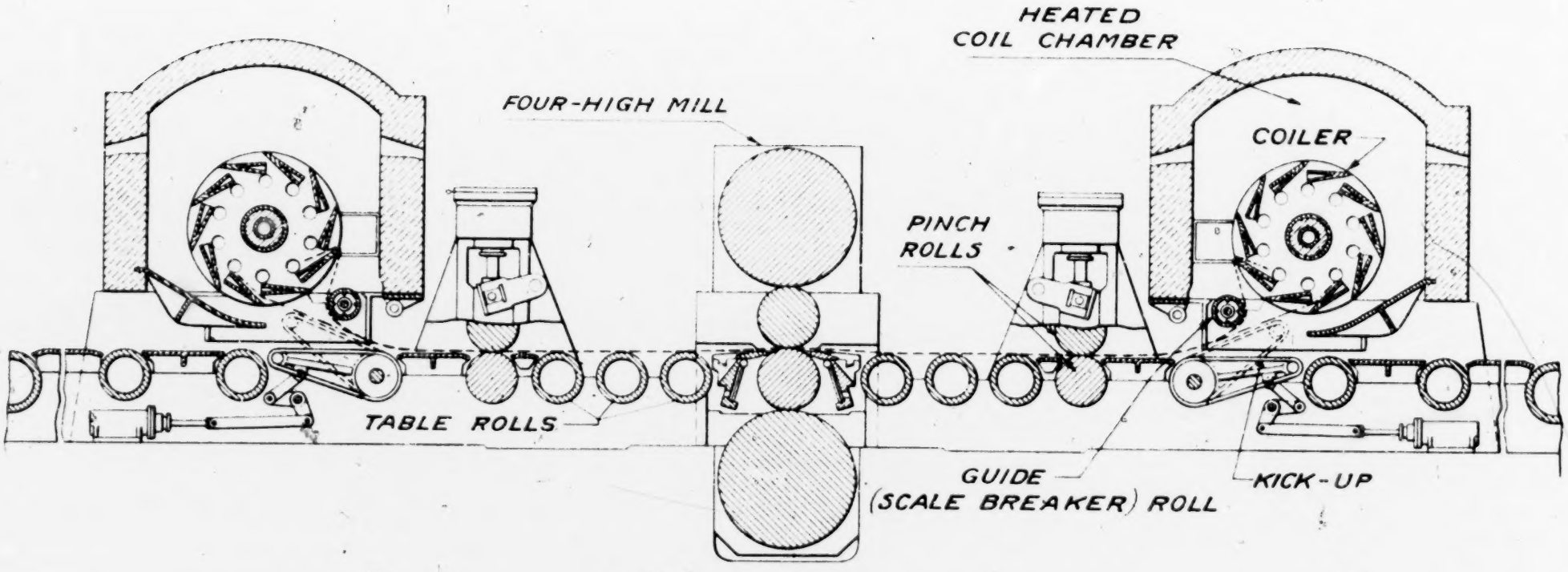
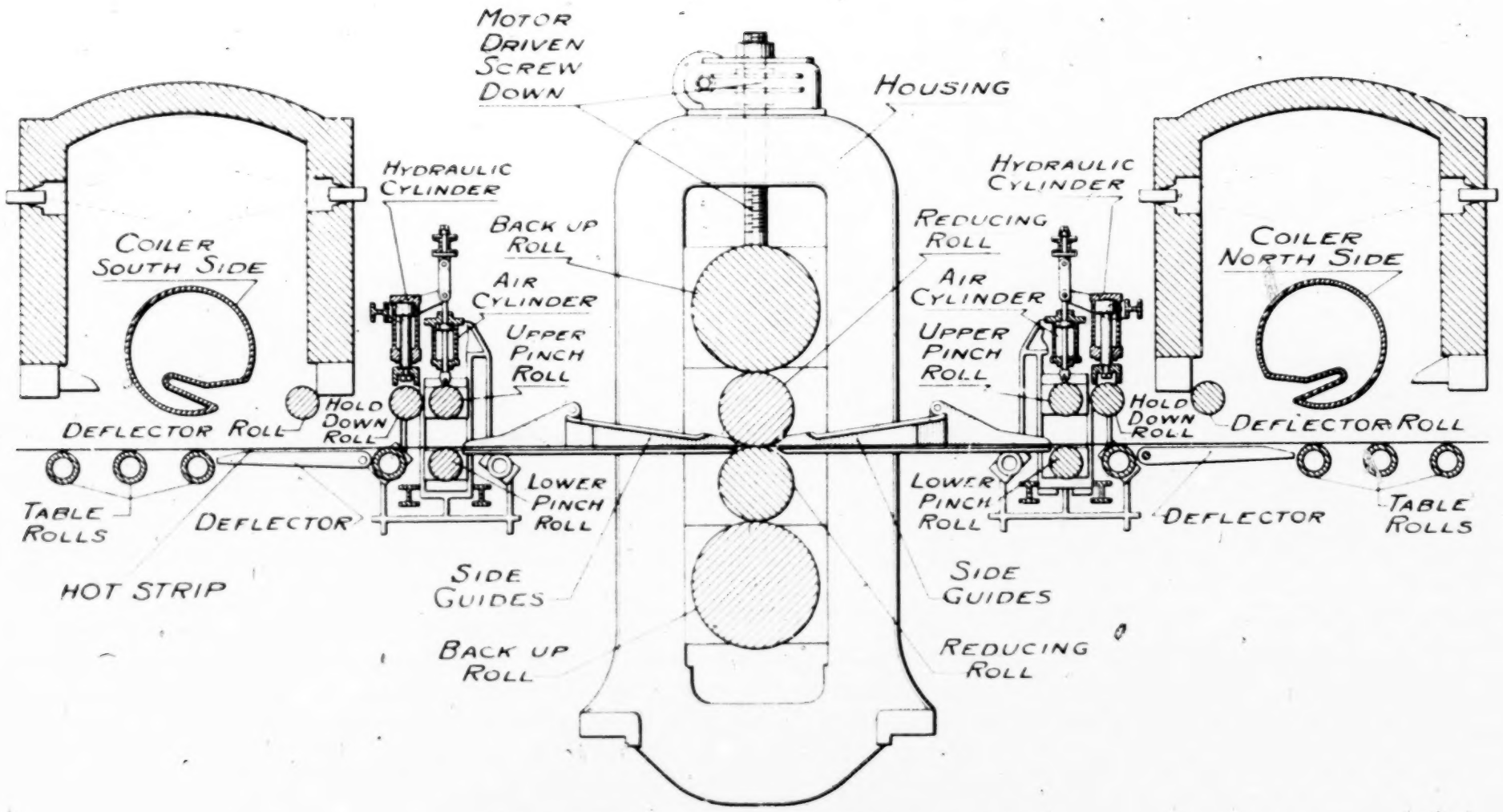


FIG. 5.

THE STECKEL '214 MILL (BASED ON FIG. 4 OF STECKEL PATENT NO. 1,977,214).

EXHIBIT D-1, Fig. 6



CRUCIBLE HOT STRIP MILL
4-HIGH REVERSING MILL STAND & COILERS

CRUCIBLE HOT STRIP MILL
4-HIGH REVERSING MILL STAND & COILERS

FIG. 6.

EXHIBIT D-1, Fig. 7

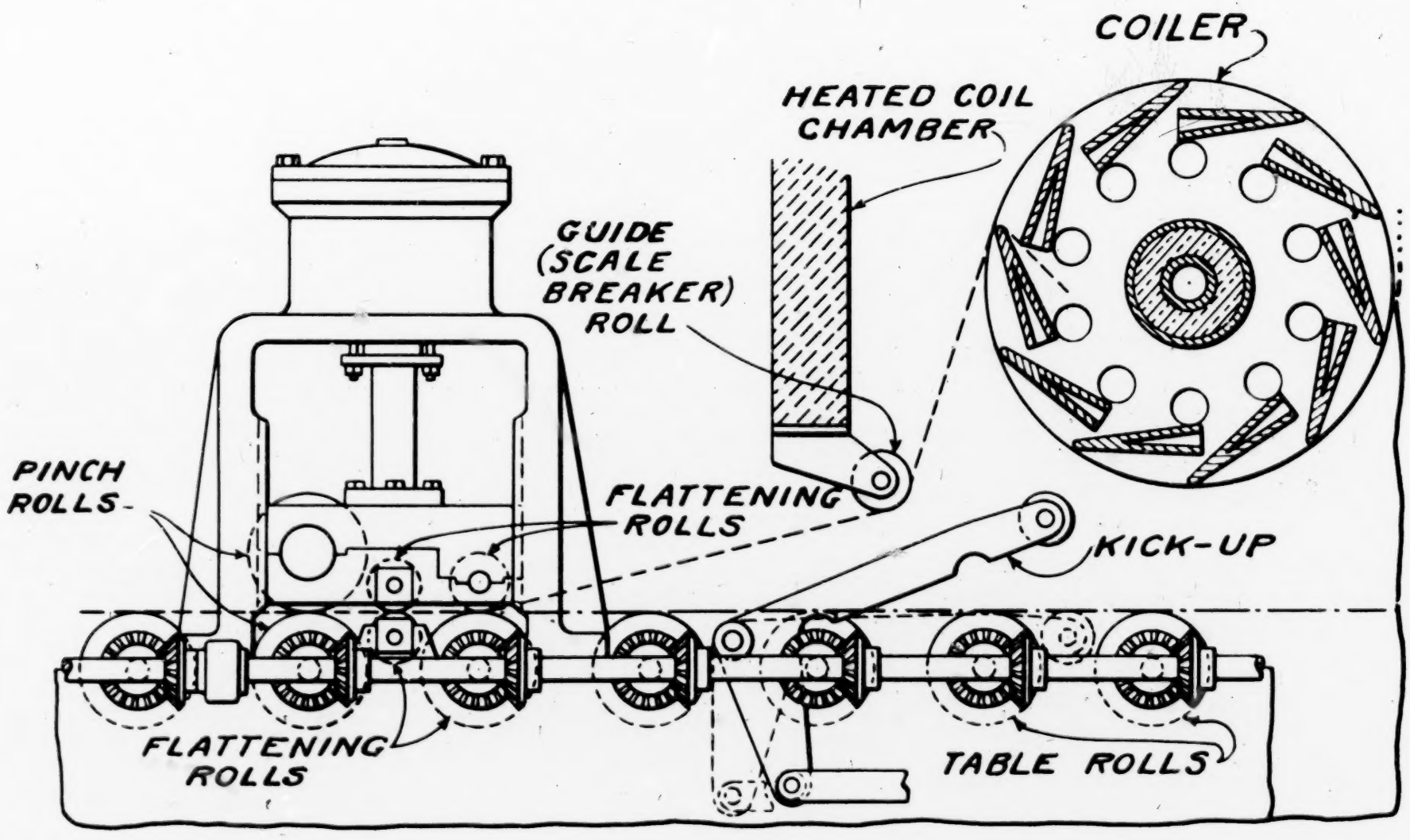


FIG. 7.

THE PINCH AND FLATTENING ROLLS AND THE COILER OF MONTGOMERY '122 (TAKEN FROM FIG. 4 OF MONTGOMERY PATENT NO 2,072,122)

EXHIBIT D-1, Fig. 8

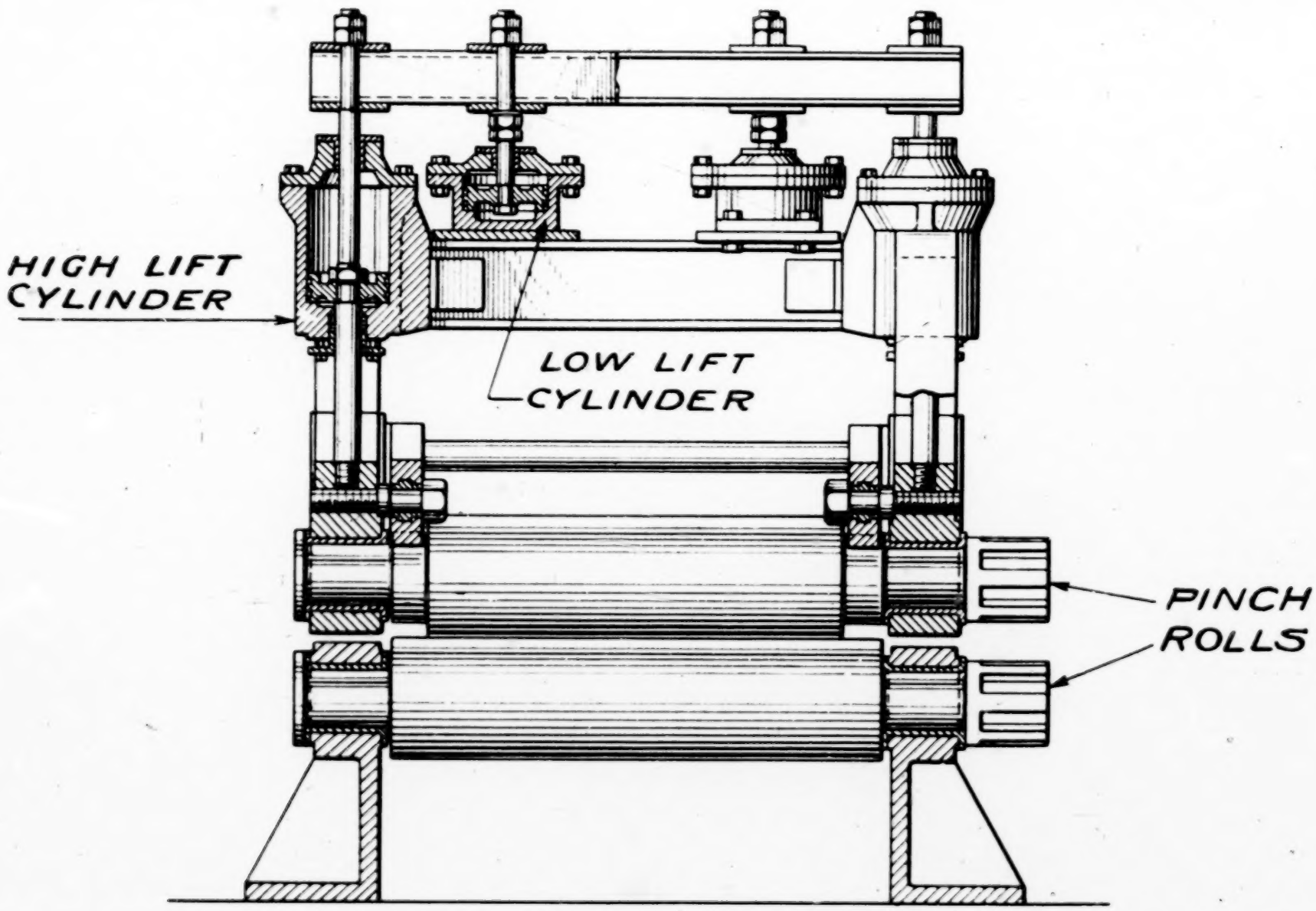
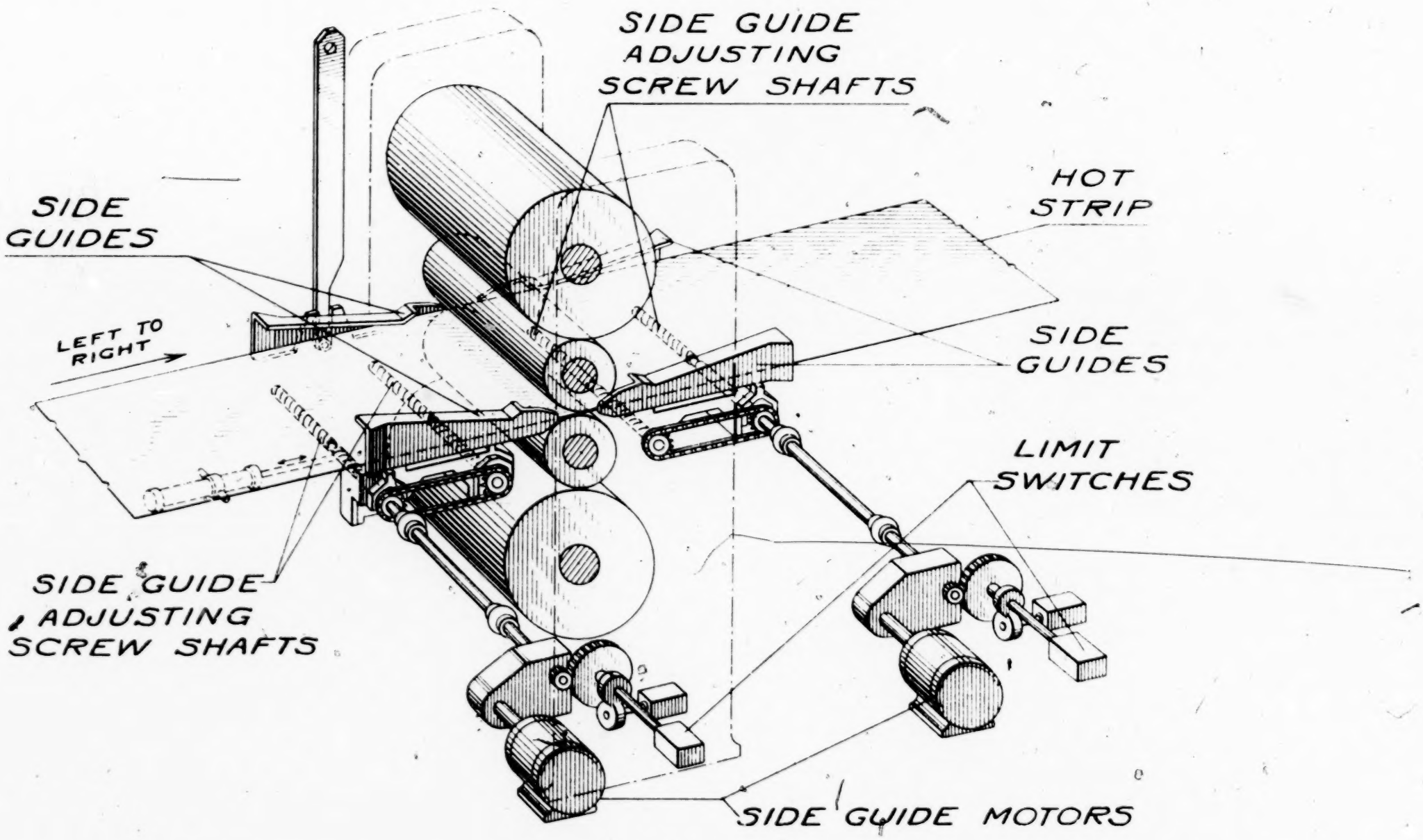


FIG. 8.

THE HIGH LIFT – LOW LIFT CYLINDERS OF MONTGOMERY '122 (TAKEN FROM FIG. 6 OF MONTGOMERY PATENT NO. 2,072,122)

EXHIBIT D-1, Fig. 9



CRUCIBLE HOT STRIP MILL

4-HIGH REVERSING MILL SIDE GUIDES

FIG. 9.

EXHIBIT D-3

UNITED STATES DISTRICT COURT

DISTRICT OF NEW JERSEY

No. 1231-52

THE COLD METAL PRODUCTS COMPANY,
Plaintiff,

v.

CRUCIBLE STEEL COMPANY OF AMERICA,
Defendant.

DESCRIPTION OF

APPARATUS AND OPERATION

OF THE

MIDLAND, PENNSYLVANIA HOT STRIP MILL

OF

CRUCIBLE STEEL COMPANY OF AMERICA

August, 1955

INDEX

	PAGE	APPENDIX PAGE
A. Drawings	1	93b
B. General Description	2	94b
C. Apparatus	3	95b
Heating Furnaces	3	95b
Roll Tables	4	96b
Scalebreaker Mill	4	96b
Roughing Mill	5	97b
4-high Reversing Mill Unit	6	98b
Mill Stand	7	99b
Side Guides	7	99b
Pinch Rolls	8	100b
Auxiliary or Hold-Down Roll	9	101b
Deflectors or Kick-Ups	10	102b
Coiler Furnaces and Coiling Reels	10	102b
Deflector Rolls	11	103b
Feed Rolls, Up-Coiler, Up-Cut Shear and Leveler	12	104b
D. Operation	12	104b
Coiling Operation Under the Original Installation	13	105b
First Pass (From North to South)	13	105b
Second Pass (From South to North)	14	106b
Third Pass (From North to South)	16	108b
Fourth Pass (From South to North)	17	109b
Succeeding Passes Including Last Pass	19	111b

	PAGE	APPENDIX PAGE
Coiling Operation Under the Modified Installation	20	112b
First Pass (From North to South)	21	113b
Second Pass (From South to North)	21	113b
Third Pass (From North to South)	23	115b
Fourth Pass (From South to North)	25	117b
Succeeding Passes Including Last Pass	27	119b
Non-Coiling Operation in Original and Modified Installations	28	120b
E. Controls	28	120b
4-High Mill Stand and Mill Rolls	29	121b
Side Guides	30	122b
Pinch Rolls and Hold-Down Rolls	33	125b
Coiling Reels	34	126b
Deflector Rolls	35	127b
Roll Tables	36	128b
Deflector	36	128b
Water and Steam Sprays	36	128b

DESCRIPTION OF

APPARATUS AND OPERATION

OF THE

MIDLAND, PENNSYLVANIA HOT STRIP MILL

OF

CRUCIBLE STEEL COMPANY OF AMERICA

The hot strip rolling mill of the Crucible Steel Company of America, located at Midland, Pennsylvania and used in the production of hot rolled strip consists of three mill stands. These are: a 32 inch by 72 inch scalebreaker mill; a roughing mill equipped with 31½ inch by 69 inch horizontal rolls and 28 inch by 34 inch vertical edging rolls; and a single stand 27 inch and 49 inch by 66 inch 4-high reversing mill equipped with coiler furnaces, coiling reels and auxiliary equipment. The hot strip mill was placed in operation as an integrated unit on an experimental basis in January of 1949. Several months of "tuning up" and changes in equipment as well as training of personnel were, however, required before commercial production was initiated on April 1, 1949.

The Crucible strip mill, as originally installed and operated, has been modified. These modifications were made primarily in the auxiliary equipment in immediate proximity to the 4-high reversing mill. In the description of the apparatus which follows, each of the modifications will be described. Similarly, the manner in which these modifications have affected the operation of the strip mill will be explained.

A. DRAWINGS

The drawings listed below correctly show the apparatus and operation of Crucible's hot strip mill at Midland, Pennsylvania, in its original and modified form, prior to the filing of the complaint herein.*

	Drawing No.
Diagrammatic Section of Complete Mill	1
4-High Reversing Mill Stand & Coilers—Plan View	2
4-High Reversing Mill Stand & Coilers—Modified Installation—Vertical Section	3

* Copies of these drawings will be found in the companion booklet, entitled "Drawings".

	Drawing No.
Vertical Section at Pinch Roll & Coiler—Original Installation	4
Vertical Section at Pinch Roll & Coiler—Modified Installation	5
Deflector & Pinch Roll Assembly—Original Installation	6
Deflector & Pinch Roll Assembly—Modified Installation	7
Pinch Roll Operation—Original Installation	8
Pinch Roll & Auxiliary Roll Operation—Modified Installation	9
Side Guide Assembly	10
Operational Drawing 1—Original Installation	11
Operational Drawing 2—Original Installation	12
Operational Drawing 3—Original Installation	13
Operational Drawing 4—Original Installation	14
Operational Drawing 5—Original Installation	15
Operational Drawing 6—Original Installation	16
Operational Drawing 7—Modified Installation	17
Operational Drawing 8—Modified Installation	18
Operational Drawing 9—Modified Installation	19
Operational Drawing 10—Modified Installation	20
Operational Drawing 11—Modified Installation	21
Operational Drawing 12—Modified Installation	22
Side Guide Positions—Diagrammatically Illustrated	23
4-High Reversing Mill Operator's Desk Panel	24
4-High Reversing Mill Assistant Operator's Desk Panel	25

B. GENERAL DESCRIPTION

Throughout the description of the Crucible hot strip mill and the operation thereof, reference will be made to the drawings listed in paragraph A above.

Crucible's hot strip mill is used primarily to hot roll relatively thick ingots and slabs into relatively thin gauge stock in long lengths,

which may be finished flat and cut to length or wound into coils, depending on the final gauge and length. In the operation, a steel ingot is first heated in a batch type furnace to a uniform temperature throughout, transferred by crane to the hot strip mill and reduced on the scalebreaker mill and roughing mill to a relatively thick slab (Drawing A-1, upper section). After the ingot has been reduced to a slab both ends of the slab are sheared off and the slab is removed by a transfer mechanism from the hot strip mill line (Drawing A-1, right end of lower section). This slab is then conditioned in the grinding shop where imperfections in the surface of the slab are removed. After conditioning the slab is returned to the hot strip mill batch type furnaces and it is again heated to a uniform temperature throughout. The slab is then transferred by crane to the roll tables of the hot strip mill. The slab is further reduced in the scalebreaker and roughing mills to a relatively long breakdown of approximately an inch or so in thickness. The breakdown is carried on the roll table leading from the roughing mill to the shear (Drawing A-1, left end of upper section) where the ends may be cropped and then into and through an initial pass between the rolls of the 4-high reversing mill (Drawing A-1, lower section). The direction of rolling in the 4-high mill is reversed following each of several passes, and if desired the strip may be coiled on reels in heated furnaces on each side of the 4-high reversing mill. After the rolling has been completed the strip is carried by the roll table to a wind-up coiler where it may be coiled, or, in the alternative, may be cut to length on an up-cut shear (Drawing A-1, left end of lower section).

C. APPARATUS

The Crucible hot strip mill involves the use of a substantial amount of apparatus described hereinafter.

Heating Furnaces

Ten batch type, side door furnaces arranged in two banks are used to heat the ingots and slabs to be rolled on the Crucible hot strip mill (Drawing A-1, right end of upper section). These furnaces supply to the material the necessary heat to place it in a sufficiently plastic condition so that the hot rolling operations can be carried out on the hot strip mill. Each of the ten furnaces has a hearth area of 660 square feet and is gas-fired. Oil is available as a standby fuel. The furnaces are charged and emptied through side doors by means of one of two avail-

able cranes. Ingots charged in these furnaces range from a 9″ x 15″ ingot to a 20″ x 55″ ingot weighing from 1,100 to 24,000 pounds. Slabs charged range from 3″ to 9″ thick, 15″ to 50″ wide to 13 feet long, and weigh from 1,000 to 10,000 pounds. The ingot or slab is heated throughout to a uniform temperature of between 2200° to 2400° F. When removed from the furnace the ingot or slab is transferred by crane to the roll table of the hot strip mill. In the reduction of an ingot to hot rolled strip, the metal is heated in these batch type furnaces on two occasions—the first in the form of an ingot and prior to any rolling, and the second in the form of a conditioned slab.

Roll Tables

Roll tables are used to convey material being rolled on the hot strip mill from the time it is delivered by crane after being withdrawn from the heating furnace until it has been rolled to finished gauge on the 4-high reversing mill and is conveyed to either the up-coiler or to the transfer mechanism for removing material cut to length by the up-cut shear. The rolls of the roll table from the furnaces to the slab transfer pusher (Drawing A-1, right end of lower section) are reversibly driven by line shaft, i.e., there are several sections of table rolls, and the rolls in each section are driven by one motor. From the transfer pusher to the leveler (Drawing A-1, left end of lower section) the rolls are driven by individual reversible motors and are rotable in either direction. In addition to these driven rollers the roll tables also have aprons extending between some of the rolls. The lower pinch roll in each pair of pinch rolls, located on each side of the 4-high reversing mill, forms a part of the roll table and each such roll is driven. The deflector positioned beneath each coiler furnace, also forms part of the roll table (Drawing A-3).

Scalebreaker Mill

The scalebreaker mill is a 2-high mill positioned immediately south of the heating furnaces. (As originally installed this mill was a non-reversing mill. In January of 1955 the drive of the scalebreaker mill was modified and it is now a reversing mill.) The slab or ingot receives one pass on the scalebreaker mill. This pass removes the heavy furnace-formed scale from the slab or ingot and also causes a reduction in thickness varying between ½ to ¾ of an inch. The rolls of the scalebreaker mill are corrugated or fluted and are 32″ in diameter and 72″ in length. The mill rolls of this mill are directly connected to a 1500

horsepower constant speed motor which operates the mill rolls at a surface speed of approximately 207 feet per minute.

Roughing Mill

The roughing mill of the hot strip mill (Drawing A-1, left end of upper section) consists of a 2-high reversing horizontal mill and a reversible vertical edging mill. The roughing mill is used to reduce ingots to slabs and to reduce the reheated slabs to breakdowns for further rolling in the 4-high reversing mill. Between 15 and 40 passes are required to reduce an ingot to a slab, the number of passes depending upon the type of metal and the desired slab thickness which may be between 3″ and 9″. When rolling in this mill from a slab to a breakdown, which may vary in thickness from ¾″ to 1½″, 9 to 15 passes are required.

The two rolls of the vertical edger are adjustable in and out, toward or away from each other, and each roll has a diameter of 28″ and a length or height of 34″. The rolls of the vertical edger are driven by a 1500 horsepower motor with a variable roll speed of between 200 to 900 feet per minute. The two horizontally mounted, reversibly driven rolls of the roughing mill are 31½″ in diameter and 69″ in length. They are driven by a 5,000 horsepower motor with a variable roll speed of between 200 to 900 feet per minute. The roll table extends on each side of the roughing mill. There are adjustable side guides extending longitudinally over the roll tables on each side of the roughing mill which align the strip for its passes through the mill. The side guides on the north side of the roughing mill are pivoted at their outer ends to fixed supports. The inner or mill ends of the guides on the north side of the roughing mill are also pivotally supported and are attached to the vertical roll housings. The inner ends of these guides move in or out depending on the movement of the vertical roll housings. These guides diverge outwardly from the mill housings to the outer pivoted supports. On the opposite or south side of the roughing mill the side guides are arranged with their opposing faces parallel to one another and are actuated independently of the mill roll housings by electrical control.

The roughing mill side guides maintain the positions described during passes in both directions in this mill, i.e., the guides on the north side always diverge away from the mill and the guides on the south side are always parallel.

After an ingot has been reduced to a slab by the roughing mill, both ends of the slab are sheared off by means of the slab shear (Drawing A-1, left end of upper section) and the slab is removed from the hot mill pass line by means of the slab transfer pusher (Drawing A-1, right end of lower section). The surface of the slab is then conditioned in the grinding shop. This surface-conditioned slab is then returned to the heating furnaces, reheated to a uniform temperature throughout of between 2200 to 2400°F. and transferred to the roll tables for further reduction to a breakdown. When the slab has been reduced to a breakdown in the roughing mill its temperature is between 1700 and 1900°F. The breakdown is passed on the roll table to the slab shear, and if the breakdown is to be reduced on the 4-high reversing mill to hot rolled strip with coiling between passes, both ends of the breakdown are sheared in the slab shear. If the material is not to be coiled between passes on the 4-high reversing mill the ends of the breakdown are not sheared at this time, but when the rolling has been completed in the 4-high mill the material is cut to sheet or plate lengths in the up-cut shear at the south end of the hot strip mill line (Drawing A-1, left end of lower section). In either case, after the slab has been reduced to a breakdown, the material, without reheating, passes on the roll table from the roughing mill to the 4-high reversing mill.

As the breakdown approaches the 4-high reversing mill unit it is sprayed both top and bottom by high pressure water sprays and steam jets for the purpose of removing scale from the breakdown. The water spray and steam jets are located a short distance from the north coiler furnace, between the slab transfer pusher and the coiler furnace (Drawing A-1, right end of lower section). The temperature of the breakdown at the time it reaches the 4-high reversing mill for the first pass is between 1600 to 1800°F., approximately 100° less than when the breakdown received its last pass on the roughing mill.

4-High Reversing Mill Unit

As originally installed and operated, this unit of the Crucible hot strip mill comprised a 4-high reversing mill stand; a roll table extending on each side of the mill stand; movable side guides on each side of the mill stand; pinch rolls on each side of the mill stand, each set consisting of a reversibly driven upper and lower roll; a coiler furnace on each side of the mill stand; a motor driven coiling reel in each coiler furnace; a deflector or billy roll adjacent the mouth of each coiler furnace, and a deflector forming a part of the roll table on each side of the mill stand

for deflecting the material into the coiling reels in the coiler furnaces (Drawings A-2 and A-4).

In the modified installation, adjacent each set of pinch rolls and between the pinch rolls and the coiler furnace is an auxiliary or hold-down roll (Drawings A-1, A-3, A-5, A-7 and A-9).

The principal component parts of this 4-high reversing mill unit, both for the modified and original installation will now be described.

Mill Stand

The 4-high reversing mill stand is shown in the drawings A-1 to A-3 and A-11 to A-22 inclusive.

The mill stand comprises a housing with four rolls mounted in the housing, one above the other. The two smaller inner rolls are the reducing or working rolls, between which the material passes as it is rolled. The two outer rolls are the backing rolls, each of which is approximately 49 inches in diameter and 66 inches long. The working rolls are approximately 27 inches in diameter and have a working face 66 inches long. These working rolls are driven by a 5,000 horsepower, 70-150 RPM direct drive electric motor through a pinion stand (Drawing A-2).

The working rolls may be moved to a position in contact with each other, or at the other extreme, to a position where they are separated a maximum of approximately 5 inches. The adjustment toward or away from each other is accomplished by means of electrically operated screw-downs controlled by the 4-high mill operator. Each screw-down is operated by a 250-volt D.C. motor. After each of the passes through the 4-high mill the rolls are brought closer together in order further to reduce the strip on the succeeding pass. The mill stand is equipped with water sprays to cool the mill rolls.

Side Guides

On each side of the 4-high reversing mill in immediate proximity to the working rolls is a set of side guides (Drawings A-1, A-2, A-3, A-10 and A-23). The two pairs of guides on opposite sides of the mill are identical.

The faces of each pair of guides are maintained parallel one to the other during rolling in either direction. The guides may be adjusted in or out, toward or away from each other, by means of threaded shafts geared to a motor having limit switches for stopping the guides at their

proper in and out positions (Drawing A-10). Each pair of guides is used as an entry or delivery guide, depending on the direction of travel of the strip. On the entry side the guides are adjusted substantially to strip width and on the delivery side, the guides are adjusted to strip width plus 5 inches (See Drawing A-23 for the two possible running positions of the guides). Each of the side guides contains several orifices for steam jets which are positioned slightly above and at an angle to the material being rolled (Drawing A-3). These steam jets are used to remove scale from the material between passes. Means for controlling the actuation of the guides will be discussed in detail hereafter.

In addition to these guides one set of adjustable side guides, installed in the Spring of 1949, is positioned immediately adjacent and to the north of the north coiler (Drawings A-1 to A-3). These guides, operated entirely independently of the parallel guides described above, are for the purpose of aligning the breakdown as it approaches the 4-high reversing mill unit.

Pinch Rolls

The pinch rolls on each side of the 4-high reversing mill stand and their operation, as originally installed, are illustrated in Drawings A-4, A-6, A-8, and A-11 to A-16. The pinch rolls and their operation, as modified, are illustrated in Drawings A-1, A-3, A-5, A-7, A-9 and A-17 to A-22. Each pair of pinch rolls is mounted in a pinch roll housing. The bottom roll is on a level with the pass line. The top roll is adjustable vertically and is mounted directly above the bottom roll. Each roll is reversibly driven by an electric motor.

As originally installed and operated, the top pinch roll of each pair of pinch rolls could be moved into one of three positions (Drawing A-8). These were: the pinch position (left-hand view), in which the strip was pinched between the two rolls; the low lift position (middle view), in which the top pinch roll was 1-½ inches above the bottom pinch roll; and the high lift position (right-hand view), in which the top pinch roll was 12 inches above the bottom roll. In the original installation each upper pinch roll was actuated into its pinch or into its high lift position by means of two identical piston actuating air cylinders mounted as an integral part of the pinch roll housing above the ends of each pair of pinch rolls. To achieve the intermediate low lift position, another air cylinder, housing a short stroke piston, and mounted midway between the ends and above each upper pinch roll, was utilized in conjunction with the two end air cylinders (Drawing A-8, middle view).

A plunger or piston operated within each air cylinder and to effect the pinch position, air under pressure (Drawing A-8, left-hand view), was introduced through the upper air line of each cylinder. To effect the high lift position the air was exhausted from above each piston and introduced under pressure through the bottom air line of each cylinder (Drawing A-8, right-hand view). To effect the low lift position the air above the piston in each of the end cylinders was airlocked (cushioned) and air under pressure was introduced through the bottom air line of the middle cylinder, causing the short stroke piston to go to its uppermost position and thus raising the upper pinch roll to a point 1-½ inches above the lower pinch roll.

In the modified installation (Drawings A-5, A-7, and A-9), and its operation (Drawings A-17 to A-22), the top pinch roll of each pair of pinch rolls may be moved into one of two positions (Drawing A-9). These are: the pinch position (left-hand view), in which the strip is pinched between the two rolls; and the up position (middle and right-hand views), in which the top pinch roll is 12 inches above the bottom pinch roll. In this modified installation each upper pinch roll is actuated to its up or to its pinch position by means of the two identical piston actuating air cylinders mounted above the ends of each pair of pinch rolls. The short stroke air cylinder previously used to actuate the upper pinch roll to its low lift position was removed by October 29, 1951.

Auxiliary or Hold-Down Roll

There was no auxiliary or hold-down roll in the original installation. In the modified installation an auxiliary or hold-down roll adjacent each pair of pinch rolls maintains the strip, when it is being coiled, below the top edges of the parallel side guides. Installation of these hold-down rolls was completed October 29, 1951. Each hold-down roll is a retractable idler roll which may occupy one of two positions (Drawing A-9). These are: the up position (left and right-hand views) in which the roll is 12 inches above the level of the pass line; and the down position (middle view) in which the roll is 3 inches above the level of the pass line. The hold-down roll is actuated to either of these positions by means of a piston actuating hydraulic cylinder independent of the air cylinders previously referred to which actuate the pinch roll. This hydraulic cylinder is positioned above and between the ends of the hold-down roll (Drawing A-7, View X-X). A plunger or piston operates within the hydraulic cylinder and to effect the up position, hydraulic fluid is introduced under pressure through the lower oil line of the

cylinder and the hydraulic fluid above the piston is exhausted through the upper oil line (Drawing A-9, left-hand view). To effect the down position hydraulic fluid under pressure is introduced through the upper oil line and exhausted from below the piston through the lower oil line (Drawing A-9, left side of middle view).

A compressed air supply is employed for raising and lowering each upper pinch roll so that it will yieldingly engage the strip being rolled. Hydraulic pressure is employed to actuate the hold-down, since it must be held rigidly in its lowered position during rolling.

The positioning of the pinch rolls and the auxiliary or hold-down roll is manually controlled by means of electric switches actuated by the operator in the manner to be described hereinafter.

Deflectors or Kick-Ups

Deflectors or kick-ups in the original and modified installations are positioned immediately in advance of and beneath the coiler furnaces (Drawing A-1, A-3 to A-7, and A-11 to A-22). Each deflector is a casting in the form of a platform consisting of a series of separated bars. The deflector may be moved from a horizontal or down-position to an elevated or up position in which it extends at an angle of approximately thirty degrees to the pass line of the material. When actuated to divert the strip into the coiler furnace the deflector is raised to its up position so that the end farthest from the 4-high mill stand is raised to a position immediately adjacent the coiling reel in the coiler furnace (Drawings A-4 and A-5).

When not employed to divert the strip into the adjacent coiler furnace the deflector is maintained in the horizontal or down position.

Each deflector is operated by means of a rocker arm connected at one end to the under-side of the deflector by means of a link and at its other end to a deflector-operating rod which in turn is connected to a deflector-operating cylinder. The deflector-operating cylinder is a hydraulic cylinder which in turn is actuated by electrical controls.

Coiler Furnaces and Coiling Reels

Above the deflectors and the roll tables are large gas-fired furnaces (oil may be used as a standby fuel) within each of which is a coiling reel for coiling the hot strip (Drawings A-1 to A-5 and A-11 to A-22).

Each furnace has an opening in the bottom through which the hot rolled strip passes as it is being wound or unwound from the coiling reel within the furnace.

The temperature in each coiler furnace is maintained between 1800°F. and 2000 F. These furnaces prevent undue heat loss in the material during the rolling.

The cylindrical coiling reel mounted in each of the furnaces has a diameter of 48″ and a face 66″ long. As originally installed each coiling reel was driven by a 150 horsepower reversible motor. In July, 1953 an additional 150 horsepower motor was added to each coiling reel driving system.

At the begianing of each pass on which the strip is to be coiled after passing through the 4-high mill, the coiling reel upon which the strip is to be wound is brought to a stop automatically with its mouth or slot positioned to receive the advancing strip (Drawings A-12 to A-14 and A-18 to A-20). The leading end of the strip goes into the slot of the coiling reel a distance of about three feet, at which time the reel is rotated in a direction having a component of movement opposite the direction of movement of the strip as it enters the reel. When rotated in this way the strip is bent over the lower lip of the coiling reel slot and thus gripped by and secured to the coiling reel, so that, as the reel continues to rotate, the strip is wound around the outer surface of the reel. When the strip is not being reeled, the coiling reels rotate slowly at idling speed to prevent warpage caused by the heat of the furnace (Drawings A-11, A-16, A-17 and A-22).

Deflector Rolls

A deflector roll (sometimes referred to as a guide or billy roll) is positioned above the deflector and beneath the inner bottom edge of the coiler furnace wall closest to the 4-high mill (Drawings A-1 to A-5 and A-11 to A-22). During winding and unwinding from the coilers the strip being rolled is bent around the deflector roll. As originally installed in January 1949 each deflector roll was an idler roll, i.e., it was not driven by motor at any time, but was turned only by frictional force resulting from contact with the strip during coiling and uncoiling from either reel. At all other times these rolls were stationary which resulted in warpage due to the furnace heat. Shortly after operations began on the original installation, i.e., within a few weeks thereafter, this arrangement was accordingly modified and a low horsepower motor was installed to drive each deflector roll. The roll was driven during reeling operations, and the direction and speed of the roll were conformed to the speed and direction of rotation of the mill rolls through interconnection with the main mill motor controller. At other times these rolls were motor-driven slowly at idling speed to prevent warping. On No-

vember 19, 1951 installation and testing of a further modification of each deflector roll was completed. As modified, each deflector roll is intermittently driven by motor—when strip is being wound or unwound from the coiling reel it is not motor driven but operates as an idler roll and hence turns only by the frictional force of the strip; when no strip is being coiled or uncoiled each deflector roll is motor driven to prevent warpage due to uneven heating by the coiler furnaces. A motor and interposed disengageable magnetic clutch drive is used for thus driving each of these deflector rolls. When motor driven the deflector rolls are interconnected with the table rolls. Starting, stopping, accelerating, or decelerating of the table rolls correspondingly starts, stops, accelerates or decelerates the deflector rolls. The electrical controls for actuating these deflector rolls will be described hereinafter.

Feed Rolls, Up-Coiler, Up-Cut Shear and Leveler

Beyond the coiler and coiler furnace on the south side of the 4-high reversing mill are positioned an up-coiler and pinch roll type feed rolls which may be used for guiding the leading end of the hot rolled strip into the up-coiler (Drawing A-1, left end of lower section). The up-coiler is used when it is desired to coil the strip after it leaves the 4-high mill on the last pass. The coiled strip is then removed from the up-coiler for further processing. If the hot rolled material is not to be coiled, the up-coiler deflector is raised above the roll table, and the material continues along the roll table under the up-coiler to the up-cut shear where it is cut to length, through the roller leveler and removed from the hot strip mill line by a transfer mechanism.

D. OPERATION

Broadly, the Crucible hot strip mill is used to produce hot rolled strip of a desired gauge and width within the capacity of the mill. The ingot is first reduced to a slab on the scalebreaker and roughing mills; the slab is conditioned and reheated; and the slab is then reduced in the scalebreaker, roughing and 4-high reversing mills to the hot rolled product of finish gauge. From April 1, 1949 to October 31, 1953 approximately 50 per cent of the material rolled was stainless steel or alloy steel, and 50 per cent was low or high carbon steel. Approximately 75 per cent of the material rolled in the 4-high reversing mill is coiled on all passes following the second pass through the reversing mill rolls in the manner to be described hereinafter, and 25 per cent is rolled "in the flat", i.e., with no coiling between any of the passes.

During a rolling operation in which the material being rolled is to be coiled between passes the material is rolled first in one direction, i.e., from north to south, and then in the reverse direction, i.e., from south to north. It is passed back and forth through the reducing rolls of the 4-high reversing mill until the final desired gauge is reached. During and after each of the passes various adjustments must be made in the apparatus in the 4-high reversing mill unit. These adjustments are made by actuation of electrical switches under the control of the men responsible for operating the mill. The controls will be described in detail hereafter.

Various changes and modifications that have been made in the apparatus of the 4-high mill unit since the original installation was placed in commercial operation have necessitated changes in the manner in which the apparatus is adjusted. For that reason a typical operation in the mill as originally operated commercially will be described, and the subsequent commercial operation of the mill for the modified installation will also be described.

Coiling Operation Under the Original Installation

As originally installed and operated, in the rolling of a breakdown to a finish gauge involving the coiling of the strip between passes the strip was not coiled on the south coiling reel adjacent the 4-high reversing mill after the first pass, but was rolled in the flat so as to reduce it in thickness sufficiently to permit of coiling it. Following the second pass through the reducing rolls, the material was coiled on the north coiling reel. Thereafter, the material was coiled and uncoiled on each pass, the material having been fed from each coil to the mill and coiled up on the other side as it issued. Coiling in one of the two coiler furnaces adjacent the 4-high mill continued up until the last pass, following which the strip was permitted to travel to the end of the run out table located south of the mill to either the up-coiler or cut to length on the up-cut shear (Drawing A-1, left end of lower section), the coiled or sheared material then having been taken away for further processing.

The following is the sequence of operations employed in the 4-high mill for rolling a breakdown to a finish gauge and employing coiling reels as described above.

First Pass (From North to South):

Before the first pass in the 4-high reversing mill, the mill unit was pre-set for the desired side guide width and mill roll spacing by the

operators. As the breakdown approached the 4-high reversing mill unit for the first pass the arrangement and operation of the apparatus of the mill unit was as follows (Drawing A-11, First Pass Started):

Mill Rolls:	Rotated at running speed in a direction to drive the strip from north to south.
North Side Guides:	Strip width and parallel.
South Side Guides:	Strip width plus 5″ and parallel.
Pinch Rolls:	High lift position.
Deflectors:	Down position.
Deflector Rolls:	Motor driven at slow idling speed.
Coiling Reels:	Rotated at slow idling speed.

Each of these parts functioned and remained in the status above described throughout the first pass and the strip was permitted to continue in the flat on the run-out table to the south of the 4-high reversing mill (Drawing A-11, First Pass Rolling). As the trailing end of the strip passed through the main mill rolls the mill was brought to a stop with the trailing end of the strip between the mill rolls and the south pinch rolls (Drawing A-11, First Pass Completed).

Second Pass (From South to North):

With the strip stopped at the mill, changes were made in the position of some of the apparatus of the mill unit in preparation for the second pass. The trailing end of the strip on the first pass became the leading end of the strip on the second pass. The guides were reset for the opposite direction of traverse. The mill was reversed by means of the Mill Master Switch and the second pass in which the strip moved from south to north began (Drawing A-2, Second Pass Started). On the second pass the strip was fed back through the mill rolls by frictional engagement with the driven table rolls. The mill rolls, table rolls, pinch rolls and deflector rolls turned at threading speed until the leading end of the strip had entered the north coiling reel slot. As set in preparation for the second pass the apparatus of the mill unit, including these changes, was as follows (Drawing A-12, Second Pass Started, Second Pass—Strip Entering Coiler on North Side):

Mill Rolls:	Brought closer together by operation of screw downs and rotated at threading speed to drive strip from south to north.
North Side Guides:	Strip width plus 5" and parallel.
South Side Guides:	Strip width and parallel.
Pinch Rolls:	High lift position (no change).
North Deflector:	Raised to up position to feed strip to coiler.
South Deflector:	Down position (no change).
North Deflector Roll:	Motor driven at threading speed.
South Deflector Roll:	Motor driven at threading speed.
North Coiling Reel:	Stopped with slot positioned to receive strip on second pass.
South Coiling Reel:	Rotated at slow idling speed (no change).

When the leading end of the strip had entered the north coiler, changes were made in the position of some of the mill unit apparatus. The apparatus, including these changes, was as follows (Drawing A-12, Second Pass During Rolling):

Mill Rolls:	Speed increased to running speed.
North Side Guides:	Strip width plus 5" and parallel (no change).
South Side Guides:	Strip width and parallel (no change).
North Pinch Rolls:	Lowered to low lift position.
South Pinch Rolls:	High lift position (no change).
North Deflector:	Lowered to down position.
South Deflector:	Down position (no change).
North Deflector Roll:	In contact with strip and motor driven at strip speed.
South Deflector Roll:	Motor driven at strip speed.

North Coiling Reel:	Rotated in clockwise direction to coil the strip.
South Coiling Reel:	Rotated at slow idling speed (no change).

The function and position of each of these parts remained the same throughout the second pass. The mill was stopped at the completion of the second pass with the trailing end of the strip between the main mill rolls and the north pinch rolls, the latter having been lowered to pinch position at this time to feed the strip back to the mill rolls on the succeeding pass (Drawing A-13, Second Pass Completed).

Third Pass (From North to South):

With the mill stopped, further changes were made in the apparatus in preparation for the third pass. The mill was again reversed by means of the Mill Master Switch and the third pass, from north to south, began. The mill unit, including these changes, was as follows (Drawing A-13, Third Pass Started):

Mill Rolls:	Brought closer together by operation of screw downs and rotated at threading speed to drive strip from north to south.
North Side Guides:	Strip width and parallel.
South Side Guides:	Strip width plus 5" and parallel.
North Pinch Rolls:	Pinch position to feed strip back to mill.
South Pinch Rolls:	High lift position (no change).
North Deflector:	Down position (no change).
South Deflector:	Raised to up position to feed strip to coiler.
North Deflector Roll:	In contact with strip and motor driven at threading speed.
South Deflector Roll:	Motor driven at threading speed.
North Coiling Reel:	Rotated to unwind strip at threading speed.
South Coiling Reel:	Stopped with slot positioned to receive strip on third pass.

After the leading end of the strip had passed between the main mill rolls the north pinch rolls were raised to the low lift position (Drawing A-13, Third Pass Entering South Coiler). When the leading end of the strip entered the south coiler, changes in the apparatus were made, and the mill unit was as follows (Drawing A-14, Third Pass Rolling):

Mill Rolls:	Speed increased to running speed.
North Side Guides:	Strip width and parallel (no change).
South Side Guides:	Strip width plus 5" and parallel (no change).
North Pinch Rolls:	Low lift position.
South Pinch Rolls:	Lowered to low lift position.
North Deflector:	Down position (no change).
South Deflector:	Lowered to down position.
North Deflector Roll:	In contact with strip and motor driven at strip speed.
South Deflector Roll:	In contact with strip and motor driven at strip speed.
North Coiling Reel:	Rotated to unwind strip at mill operating speed.
South Coiling Reel:	Rotated in counterclockwise direction to coil the strip.

The function and position of each of these parts remained the same throughout the third pass. The mill was stopped at the completion of the pass with the trailing end of the strip between the main mill rolls and the south pinch rolls, the latter having been lowered to pinch position at this time to feed the strip back to the mill rolls on the succeeding pass (Drawing A-14, Third Pass Completed).

Fourth Pass (From South to North):

Again, with the mill stopped further changes were made in the position of the apparatus in preparation for the fourth pass. The mill was again reversed by means of the Mill Master Switch and the fourth

pass, from south to north, began. The mill unit then appeared as follows (Drawing A-14, Fourth Pass Started):

Mill Rolls:	Brought closer together by operation of screw downs and rotated at threading speed to drive the strip from south to north.
North Side Guides:	Strip width plus 5" and parallel.
South Side Guides:	Strip width and parallel.
North Pinch Rolls:	Raised to high lift position.
South Pinch Rolls:	Pinch position to feed strip back to mill.
North Deflector:	Raised to up position to feed strip to coiler.
South Deflector:	Down position (no change).
North Deflector Roll:	Motor driven at threading speed.
South Deflector Roll:	In contact with strip and motor driven at threading speed.
North Coiling Reel:	Stopped with slot positioned to receive strip on fourth pass.
South Coiling Reel:	Rotated to unwind strip at threading speed.

After the leading end of the strip had passed between the mill rolls the south pinch rolls were raised to the low lift position (Drawing A-15, Fourth Pass Entering North Coiler). When the leading end of the strip entered the north coiler additional changes were made in the position of the apparatus and the mill was as follows (Drawing A-15, Fourth Pass Rolling):

Mill Rolls:	Speed increased to running speed.
North Side Guides:	Strip width plus 5" and parallel (no change).
South Side Guides:	Strip width and parallel (no change).
North Pinch Rolls:	Lowered to low lift position.
South Pinch Rolls:	Low lift position.

North Deflector:	Lowered to down position
South Deflector:	Down position (no change).
Deflector Rolls:	In contact with strip and motor driven at strip speed.
North Coiling Reel:	Rotated in clockwise direction to coil the strip.
South Coiling Reel:	Rotated to unwind strip at mill operating speed.

The function and position of each of these parts remained the same throughout the fourth pass. The mill was stopped at the completion of the fourth pass with the trailing end of the strip between the mill rolls and the north pinch rolls, and at this time the north pinch rolls were lowered to pinch position to feed the strip back to the mill on the succeeding pass (Drawing A-15, Fourth Pass Completed).

Succeeding Passes Including Last Pass

The strip received five or seven passes in the 4-high reversing mill in normal operation, depending upon the material being rolled and the final desired thickness. If the strip was to receive seven passes, the strip was coiled on the south coiling reel after the fifth pass in a manner similar to the third pass as described. Similarly, on the sixth pass the strip was coiled on the north coiling reel and the pass was made in the same manner as the fourth pass.

After the mill was stopped on the next to the last pass with the strip coiled on the north coiling reel, in addition to lowering the north pinch rolls to pinch position, further changes were made in the position of the apparatus of the mill unit in preparation for the last pass. The mill was again reversed by means of the Mill Master Switch and the last pass from north to south began. Threading speed was not used on the last pass. At this time the mill unit was as follows (Drawing A-16, Final Pass Started):

Mill Rolls:	Brought to final gauge position by operation of the screw downs, and rotated at running speed to drive strip from north to south.
North Side Guides:	Strip width and parallel.
South Side Guides:	Strip width plus 5″ and parallel.

North Pinch Rolls:	Pinch position.
South Pinch Rolls:	Raised to high lift position.
North Deflector:	Down position (no change).
South Deflector:	Down position (no change).
North Deflector Roll:	In contact with strip and motor driven at strip speed.
South Deflector Roll:	Motor driven at strip speed.
North Coiling Reel:	Rotated to unwind strip at mill operating speed.
South Coiling Reel:	Rotated slowly at idling speed.

The leading end of the strip passed through the main mill rolls, beneath the south coiler furnace and on out the run-out tables. After the leading end of the strip had passed through the main mill rolls the north pinch rolls were raised to low lift position, and the function and position of the apparatus remained the same throughout the last pass (Drawing A-16, Final Pass During Rolling).

After the last pass the apparatus of the 4-high reversing mill unit was re-set by means of electric switches in preparation for rolling the next breakdown and the operation as described was repeated.

Coiling Operation Under the Modified Installation

The principal modifications and changes in the 4-high reversing mill unit that have been made since the mill was placed in commercial operation and that materially alter the operation of the mill are:

(1) Installation of the auxiliary or hold-down roll (*ante*, pp. 9-10), and removal of the intermediate or low lift position from the pinch rolls (*ante*, pp. 8-9).

(2) Installation of the magnetic clutch for intermittent actuation of the deflector roll drive (*ante*, pp. 11-12, *post*, pp. 35-36).

(3) Side guide actuation: several modifications made as explained (*post*, pp. 30-32).

As in the original installation (*ante*, p. 13) the strip is not coiled on the south coiling reel after the first pass but is rolled in the flat so as to reduce it in thickness sufficiently to permit of coiling it. Following the second pass through the reducing rolls the material is coiled on the

north coiling reel. Thereafter the material is coiled and uncoiled on each pass, the material being fed from each coil to the mill and coiled up on the other side as it issues. Coiling in one of the two coiling furnaces adjacent the 4-high mill continues up until the last pass, following which the strip is permitted to travel to the end of the run-out table located south of the mill to either the up-coiler or cut to length on the up-cut shear. The coiled or sheared material is then removed for further processing. As in the original installation the mill unit is pre-set by the mill operator depending upon the width and gauge of the material to be rolled.

First Pass (From North to South):

As the breakdown approaches the 4-high reversing mill unit for the first pass the positioning of the apparatus of the mill unit is as follows (Drawing A-17, First Pass Started):

Mill Rolls:	Rotating at running speed in a direction to drive strip from north to south.
North Side Guides:	Strip width and parallel.
South Side Guides:	Strip width plus 5" and parallel.
Pinch Rolls:	Up position.
Hold Down Rolls:	Up position.
Deflectors:	Down position.
Deflector Rolls:	Motor driven at strip speed.
Coiling Reels:	Rotating at slow idling speed.

Each of these parts functions and remains in the positions described throughout the first pass and the strip is permitted to continue in the flat on the run-out table to the south of the 4-high reversing mill (Drawing A-17, First Pass Rolling). As the trailing end of the strip passes through the main mill rolls, the mill is brought to a stop with the trailing end of the strip between the mill rolls and the south pinch rolls (Drawing A-17, First Pass Completed).

Second Pass (From South to North):

With the strip stopped at the mill, changes are made in the position of some of the apparatus of the mill unit in preparation for the second pass. The mill is reversed by means of the Mill Master Switch and the

second pass in which the strip moves from south to north commences. On the second pass the strip is fed back through the mill rolls by frictional engagement with the driven table rolls. The mill rolls, table rolls, pinch rolls and south deflector roll turn at threading speed until the leading end of the strip has entered the north coiling reel slot. As set in preparation for the second pass the operation of the mill unit, including these changes, is as follows (Drawing A-18, Second Pass Started; Second Pass—Strip Entering Coiler on North Side):

Mill Rolls:	Brought closer together by operation of screw downs and rotating at threading speed to drive strip from south to north.
North Side Guides:	Strip width plus 5″ and parallel.
South Side Guides:	Strip width and parallel.
Pinch Rolls:	Up position (no change).
Hold Down Rolls:	Up position (no change).
North Deflector:	Raised to up position to feed strip to coiler.
South Deflector:	Down position (no change).
North Deflector Roll:	Not turning.
South Deflector Roll:	Motor driven at strip speed.
North Coiling Reel:	Stopped with slot positioned to receive strip on second pass.
South Coiling Reel:	Rotating at slow idling speed (no change).

When the leading end of the strip has entered the north coiler, changes are made in the position of some of the mill unit apparatus. The apparatus, including the changes, is as follows (Drawing A-18, Second Pass During Rolling):

Mill Rolls:	Speed increased to running speed.
North Side Guides:	Strip width plus 5″ and parallel (no change).
South Side Guides:	Strip width and parallel (no change).

Pinch Rolls:	Up position (no change).
North Hold Down Roll:	Lowered to down position.
South Hold Down Roll:	Up position (no change).
North Deflector:	Lowered to down position.
South Deflector:	Down position (no change).
North Deflector Roll:	In contact with strip and turned by frictional force of strip.
South Deflector Roll:	Motor driven at strip speed (no change).
North Coiling Reel:	Rotated in clockwise direction to coil the strip.
South Coiling Reel:	Rotating at slow idling speed (no change).

The function and position of each of these parts remain the same throughout the second pass. The mill is stopped at the completion of the second pass with the trailing end of the strip between the main mill rolls and the north pinch rolls, the latter being lowered at this time to pinch position to feed the strip back to the mill rolls on the succeeding pass (Drawing A-19, Second Pass Completed).

Third Pass (From North to South):

With the mill stopped further changes are made in the apparatus in preparation for the third pass. The mill is again reversed by means of the Mill Master Switch and the third pass, from north to south, begins. The mill unit, including these changes, is as follows (Drawing A-19, Third Pass Started):

Mill Rolls:	Brought closer together by operation of screw downs and rotating at threading speed to drive strip from north to south.
North Side Guides:	Strip width and parallel.
South Side Guides:	Strip width plus 5" and parallel.
North Pinch Rolls:	Pinch position to feed strip back to mill.
South Pinch Rolls:	Up position (no change).

North Hold Down Roll:	Down position (no change).
South Hold Down Roll:	Up position (no change).
North Deflector:	Down position (no change).
South Deflector:	Raised to up position to feed strip to coiler.
North Deflector Roll:	In contact with strip and turned by frictional force of strip.
South Deflector Roll:	Not turning.
North Coiling Reel:	Rotated to unwind strip at threading speed.
South Coiling Reel:	Stopped with slot positioned to receive strip on third pass.

As soon as the leading end of the strip has passed between the main mill rolls the north pinch rolls are raised to up position (Drawing A-19, Third Pass Entering South Coiler). When the leading end of the strip has entered the south coiler further changes in the position of the apparatus are made, and the apparatus is as follows (Drawing A-20, Third Pass Rolling):

Mill Rolls:	Speed increased to running speed.
North Side Guides:	Strip width and parallel (no change).
South Side Guides:	Strip width plus 5" and parallel (no change).
North Pinch Rolls:	Up position.
South Pinch Rolls:	Up position (no change).
North Hold Down Roll:	Down position (no change).
South Hold Down Roll:	Lowered to down position.
North Deflector:	Down position (no change).
South Deflector:	Lowered to down position.
North Deflector Roll:	In contact with strip and turned by frictional force of strip.

South Deflector Roll:	In contact with strip and turned by frictional force of strip.
North Coiling Reel:	Rotated to unwind strip at mill operating speed.
South Coiling Reel:	Rotated in counter-clockwise direction to coil the strip.

The function and position of each of these parts remain the same throughout the third pass. The mill is stopped at the completion of the pass with the trailing end of the strip between the main mill rolls and the south pinch rolls, the latter being lowered to pinch position at this time to feed the strip back to the mill on the succeeding pass (Drawing A-20, Third Pass Completed).

Fourth Pass (From South to North):

Again, with the mill stopped further changes are made in preparation for the fourth pass. The mill is again reversed by means of the Mill Master Switch and the fourth pass from south to north begins. The mill is then as follows (Drawing A-20, Fourth Pass Started):

Mill Rolls:	Brought closer together by operation of screw downs and rotated at threading speed to drive the strip from south to north.
North Side Guides:	Strip width plus 5" and parallel.
South Side Guides:	Strip width and parallel.
North Pinch Rolls:	Up position (no change).
South Pinch Rolls:	Pinch position to feed strip back to mill.
North Hold Down Roll:	Raised to up position.
South Hold Down Roll:	Down position (no change).
North Deflector:	Raised to up position to feed strip to coiler.
South Deflector:	Down position (no change).
North Deflector Roll:	Not turning.

South Deflector Roll:	In contact with strip and turned by frictional force of strip.
North Coiling Reel:	Stopped with slot positioned to receive strip on fourth pass.
South Coiling Reel:	Rotated to unwind strip at threading speed.

After the leading end of the strip has passed between the main mill rolls the south pinch rolls are raised to up position (Drawing A-21, Fourth Pass Entering North Coiler). When the leading end of the strip has entered the north coiler additional changes are made in the position of the apparatus and the mill is as follows (Drawing A-21, Fourth Pass Rolling):

Mill Rolls:	Speed increased to running speed.
North Side Guides:	Strip width plus 5" and parallel (no change).
South Side Guides:	Strip width and parallel (no change).
North Pinch Rolls:	Up position (no change).
South Pinch Rolls:	Up position.
North Hold Down Roll:	Lowered to down position.
South Hold Down Roll:	Down position (no change).
North Deflector:	Lowered to down position.
South Deflector:	Down position (no change).
Deflector Rolls:	In contact with strip and turned by frictional force of strip.
North Coiling Reel:	Rotated in clockwise direction to coil the strip.
South Coiling Reel:	Rotated to unwind strip at mill operating speed.

The function and position of each of these parts remain the same throughout the fourth pass. The mill is stopped at the completion of the fourth pass with the trailing end of the strip between the mill rolls

and the north pinch rolls, and at this time the north pinch rolls are lowered to pinch position to feed the strip back to the mill on the succeeding pass (Drawing A-21, Fourth Pass Completed).

Succeeding Passes Including Last Pass

As in the original installation the strip may receive either five or seven passes. The strip, which will move in a direction of north to south on the last pass is not coiled on the south coiling reel on the last pass but continues along the run-out tables to the up-coiler or up-cut shear at the south end of the mill line.

After the mill has been stopped on the next to the last pass with the strip coiled on the north coiling reel, in addition to lowering the north pinch rolls to pinch position, further changes are made in apparatus of the mill unit in preparation for the last pass. The mill is again reversed by means of the Mill Master Switch and the last pass from north to south begins. Threading speed is not used on the last pass. At this time the mill unit is as follows (Drawing A-22, Final Pass Started):

Mill Rolls:	Brought to final gauge position by operation of screw downs and rotating at running speed to drive the strip from north to south.
North Side Guides:	Strip width and parallel.
South Side Guides:	Strip width plus 5″ and parallel.
North Pinch Rolls:	Pinch position to feed strip back to mill.
South Pinch Rolls:	Up position (no change).
North Hold Down Roll:	Down position (no change).
South Hold Down Roll:	Raised to up position.
North Deflector:	Down position (no change).
South Deflector:	Down position (no change).
North Deflector Roll:	In contact with strip and turned by frictional force of strip.
South Deflector Roll:	Motor driven at strip speed.

North Coiling Reel:	Rotating to unwind strip at mill operating speed.
South Coiling Reel:	Rotated slowly at idling speed.

After the leading end of the strip has passed through the main mill rolls the north pinch rolls are raised to the up position, and the function and position of the apparatus remain the same throughout the last pass (Drawing A-22, Final Pass During Rolling).

After the last pass the apparatus of the 4-high reversing mill unit is reset in preparation for rolling the next breakdown and the operation as described is repeated.

Non-Coiling Operation in Original and Modified Installations

As previously noted (*ante*, p. 12), approximately 25 per cent of the rolling in the 4-high reversing mill is performed in the flat, i.e., with no coiling between the reducing passes. This flat rolling operation is the same for the modified operation as it was in the original installation. The material is fed to the 4-high reversing mill from the roughing mill and passed back and forth through the reducing rolls of the 4-high mill in the flat condition until the final desired gauge is reached. No use is made of the deflectors, coiling reels, deflector rolls, pinch rolls or auxiliary rolls in the flat rolling operation. The side guides are used to align the strip as in a coiling pass. The frictional contact between the material being rolled and the rolls of the roll table is sufficient to feed the strip into the reducing rolls of the mill. When the desired gauge is reached the material is passed along the run-out table where it is sheared, levelled and removed by the transfer mechanism (Drawing A-1, left end of lower section).

E. CONTROLS

The Crucible hot strip mill is electrically controlled, and is under the immediate supervision of a foreman, called the Roller. The scale-breaker mill is under the control of one operator. The roughing mill is under the control of two operators, one controlling the horizontal rolls and one controlling the vertical edger. The 4-high reversing mill unit is under the control of an Operator and an Assistant Operator. In addition, there are several other workmen essential to the overall operation of the hot strip mill.

There are two control panels for controlling the 4-high reversing mill unit, one designated the "Operator's Desk Panel" (Drawing A-24) which is located in a pulpit a short distance from the hot strip mill line and opposite the north coiler furnace, and the other designated the "Assistant Operator's Desk Panel" (Drawing A-25) which is located in a pulpit opposite the south coiler furnace. The Operator occupies the north pulpit and the Assistant Operator the south pulpit. The panels (Drawings A-24 and A-25) include controls for actuating the various components of the 4-high reversing mill unit, i.e., the screw downs, the mill rolls, side guides, pinch rolls, auxiliary or hold-down rolls, deflectors, deflector rolls, coiling reels, scale removal sprays and the table rolls in the immediate vicinity of the 4-high reversing mill unit.

By means of these controls the apparatus of the 4-high reversing mill unit is properly positioned prior to and during the rolling operation. The actuation of the apparatus will now be described.

4-High Mill Stand and Mill Rolls

The spacing of the driven working rolls of the 4-high mill is controlled by the Operator from the north pulpit. These rolls are pre-set by the screw downs for the first pass and between succeeding passes the rolls are brought closer together until the final gauge desired is reached.

The speed and direction of rotation of the rolls and the resulting rate of travel of the strip is controlled by the Operator. Certain of the apparatus of the 4-high reversing mill unit is tied in with the mill speed control, i.e., the direction and speed of rotation of the table rolls, pinch rolls and coilers must be coordinated with the direction and speed of rotation of the mill rolls during the rolling operation.

The Operator regulates the speed and direction of travel from his panel through the Mill Master Switch (Drawing A-24). This switch has five possible positions. These are (1) "Off", at which position the mill, table rolls, pinch rolls and coilers are stopped; (2) and (3) "Threading" (either left or right), at which positions the mill rolls, etc., will turn at a speed of from 250 to 450 feet per minute, and which are used during a coiling pass when the leading end of the strip is being fed into the mill rolls and until the strip has been secured through one or two turns on either coiling reel; and (4) and (5) "Running" (either left or right), at which positions the mill rolls and other equipment

turn at a speed of from 300 to 1200 feet per minute, and which are used after the strip has been secured to either coiling reel, on the last pass, or at all times during the running of a flat pass. The particular threading or running speed desired is controlled by independent setting of the Thread Speed Selector Switch or Running Spped Selector Switch (Drawing A-24).

In addition to controlling the speed and direction of travel of the strip, the actuation of the parallel side guides to their proper entry or delivery positions may be tied in by automatic control to the Mill Master Switch in the manner to be described hereinafter. The side guides also may be actuated by independent push button control.

In addition to the Mill Master Switch on the Operator's control panel, the Assistant Operator has access to a Mill Stop Button (Drawing A-25). In the event of any electrical, mechanical or operational failure during rolling, and if the Operator fails to stop the mill with the Mill Master Switch, the Assistant Operator may actuate his Mill Stop Button and completely de-energize the mill.

Side Guides

Each set of guides immediately adjacent the 4-high reversing mill stand is adjusted in and out by m ans of an independent reversibly driven motor through a threaded shaft and gearing arrangement. Prior to the running of a particular width of strip in the 4-high reversing mill each set of guides is preset from the desk panels by actuation of the Side Guide Adjustment Switch (Drawings A-24 and A-25) so that when functioning as entry guides the guides will be at approximately strip width with their opposing faces parallel one to the other. When functioning as delivery guides they will be strip width plus five inches with their opposing faces parallel (Drawing A-23). The limiting adjustments of each set of guides to the entry or delivery position by actuation of the independent guide motors is effected by means of a limit switch. This limit switch contains a pair of cam actuated contacts which are preset for limiting the entry and delivery positions of each pair of guides to that desired for the width of strip being rolled.

The actuation of these side guides has been effected in several different ways since the Crucible hot strip mill was placed in commercial operation in April of 1949. For approximately one year thereafter, each set of guides was operated independently of the other. A side guide operator was stationed on each side of the mill, and by means of

lever actuated electrical control circuits, would adjust the guides on his side in or out depending on the direction of travel of the strip. Both sets of guides also could be operated by one side guide operator. This method of operation will be referred to as the "independent manual" side guide control.

In January of 1950 control of the guides was tied in with the Mill Master Switch in such manner that when the Master Switch was positioned to energize the mill to move the strip from right to left (north to south), the north guides would serve as entry guides and would move to entry position, and the south guides would serve as delivery guides and would move to delivery position. When the Mill Master Switch was positioned to energize the mill to move the strip from left to right (south to north) the function and position of the guides would automatically reverse, i.e., the south guides would move to the entry position and the north guides to the delivery position. The two independent side guide motors were arranged to be oppositely driven for any given side guide adjustment. Thus, when one guide motor was energized to adjust its guides inwardly to assume entry position, the other guide motor was energized to concurrently adjust its guides in the opposite direction, i.e., outwardly to assume delivery position. Under this arrangement, which will be referred to as the "direct actuation-automatic" side guide control, the guides would not move to their proper positions for a given pass until the mill had been energized to move the strip in the direction for which the Mill Master Switch was set. This method of guide adjustment proved unsatisfactory since the guides and the strip were concurrently in motion, the guides therefore being ineffective and productive of jamming of the strip in the guides.

For this reason the mode of controlling and adjusting the guides was further modified in the summer of 1950. This modification, in which actuation of the guides was also tied in with the Mill Master Switch, served to effect movement of the side guides to their appropriate positions for the next pass automatically after the mill had been brought to a stop, and before the strip began to move on the next succeeding pass. With this modification, which will be referred to as the "anticipatory-automatic" side guide control, adjustment of the guides was effected only with the Mill Master Switch in the "Off" position. Thus, for the first pass through the 4-high reversing mill the north guides will have been set as entry guides (strip width) and the south guides will have been set as delivery guides (strip width plus five inches). During the first pass the Mill Master Switch is positioned

to energize the mill to move the breakdown from right to left through the mill. As the strip completes its first pass the Mill Master Switch is moved to "Off" position, deenergizing the mill to arrest further movement of the breakdown. Placing the Mill Master in the "Off" position, energizes electrical relay circuits to adjust both sets of guides automatically and simultaneously to their opposite limits, i.e., the guides serving as delivery guides on the first pass move in to the entry guide position and the guides serving as entry guides on the first pass move out to delivery guide position. This rearrangement of the guides for the second pass is thus completed prior to energizing the mill motor to move the strip from left to right (south to north) on the second pass. With the Mill Master Switch in position to move the strip from left to right the guides remain locked in their proper positions throughout the pass. As the strip completes its second pass the Master Switch is again placed on "Off" position to stop the mill and the side guides are thereby automatically adjusted to their opposite positions properly to guide the strip for its third pass from right to left.

On January 21, 1952, a still further modification was completed in the side guide control system. This modification involved the installation of manually actuated push button controls, and will be referred to as the "push button" side guide control. With the side guides operating by push button control, actuation of the guides from one limit position to the other is normally effected only when the Mill Master Switch is in "Off" position. The Mill Guides Button (Drawing A-25) is then depressed. This actuation, like that described for the "anticipatory automatic" side guide control, also occurs prior to commencement of movement of the strip. Thus, when the strip has been running from right to left and the Mill Master Switch is moved to "Off" position, the Mill Guides Button is depressed and the south guides will change from delivery to entry position and the north guides will change from entry to delivery position. The succeeding pass will then be started. Each pair of guides remains in its respective position until the next succeeding time the Mill Guides Button is depressed after the Mill Master Switch is returned to "Off" position, at which time the function and position of each pair of guides will be reversed by depressing the Mill Guides Button. The Assistant Operator operates the "push button" side guide control from the south pulpit irrespective of the direction of rolling in the mill.

Interchange between the last two modifications ("anticipatory automatic" and "push button") of the side guide control system may be made by throwing a gang switch located on a separate switch panel.

Pinch Rolls and Hold-Down Rolls

As originally installed each of the top pinch rolls could be actuated to any one of its three positions by means of a manually operated rotary electric switch. The switch for operating the north upper pinch roll was located on the Operator's control desk. The Assistant Operator controlled the south upper pinch roll from his control desk. Each pinch roll control switch was rotatable to any one of three actuating positions: "High Lift", "Low Lift" and "Pinch." Each switch position was connected by suitable electrical circuits to solenoid actuated air valves which in operation selectively introduced or exhausted air from the various pinch roll air cylinder and piston assemblies to bring the top roll to its proper position.

In the modified pinch roll and hold-down roll assembly, installation and testing of which was completed on October 29, 1951, actuation of the upper pinch roll to the proper one of its two possible positions ("up" or "pinch"), or the hold-down roll to the proper one of its two possible positions ("up" or "down"), is also effected by a manually operated rotary switch for each pinch and hold-down roll assembly, the Operator controlling the north side and the Assistant Operator the south side. Each switch may be rotated to any one of four actuating positions. In the first position the upper pinch roll and hold-down roll are lowered to their lowermost positions—pinch position for the upper pinch roll and 3 inches above the material pass line for the hold-down roll. In its second position the upper pinch roll and hold-down roll are raised to their uppermost positions, 12 inches above the material pass line. In the third position the upper pinch roll alone is lowered to its pinch position and the hold-down roll either remains in or returns to its uppermost position. In the fourth position the hold-down roll is lowered to its lowermost position and the upper pinch roll either remains in or returns to its uppermost position. Thus, by proper positioning of this selector switch both the pinch and hold-down rolls may be elevated or lowered to all possible positions either concurrently or selectively. The selector switch may be moved from any of its four positions to any other of its four positions as desired. Each selector switch position is connected to suitable relay circuits for selectively actuating a solenoid controlled air valve for actuation of the pinch roll and a solenoid controlled hydraulic valve for actuation of the hold-down roll.

Coiling Reels

Each of the coiling reels of the 4-high reversing mill unit is electrically driven by means of two 150 horsepower reversible motors. As originally installed one 150 horsepower motor was used to drive each reel. In July of 1953 an additional 150 horsepower motor was added to each coiling reel. The north coiling reel is controlled by the Operator and the south coiling reel is controlled by the Assistant Operator. Each coiling reel is actuated by two control switches, the Coiler Selector Switch and the Coiler Master Switch (Drawings A-24 and A-25).

Each Coiler Selector Switch has four possible positions. These positions and the resulting actuation of the coiling reel are as follows:

(1) "Off". This position is used to stop the coiling reel.

(2) "Idle". With the Coiler Selector Switch placed in the "Idle" position the coiling reel will turn at a slow idling speed. This position of the Coiler Selector Switch is used when the coiling reels are not being utilized—when the strip is being rolled in the flat without coiling between passes, or when no strip is being rolled in the 4-high reversing mill. Both Coiler Selector Switches occupy this position during the initial pass from north to south in the 4-high reversing mill.

(3) "Normal". The Coiler Selector Switch is placed in the "Normal" position during a rolling and coiling operation. The Coiler Selector Switch will remain in "Normal" position throughout the remaining rolling and coiling passes. The second coiling reel control switch, called the Coiler Master Switch, is used in conjunction with the Coiler Selector Switch during this period. The Coiler Master Switch has two possible positions—"Off" and "On"—and is effective only when the Coiler Selector Switch is in the "Normal" position. At this time the Coiler Master Switch, when placed in "Off" position, stops the coiling reel with its mouth ready to receive the leading end of the strip at the beginning of a coiling pass. With the Coiler Selector Switch remaining in "Normal" position, the Coiler Master Switch, when moved to its "On" position, will cause the coiling reel to rotate at a speed and in a direction commensurate with the speed of the main mill rolls as controlled by the Operator through the Mill Master Switch (*ante*, pp. 29-30).

When the Coiler Selector Switch is in "Normal" position the magnetic clutch of the deflector roll drive is disengaged and the deflector

roll functions as a non-driven idler roll, being turned, when in contact with the strip, by frictional engagement with the strip.

(4) "Jog". As originally operated the Coiler Selector Switch was placed in the "Jog" position when it was desired to move the coiling reel around by small increments. Jogging the reel (moving it around little by little) is now accomplished by making and breaking the circuit at the "Idle" control point of the Coiler Selector Switch.

The motor drives of the coiling reels are so controlled as to tend to drive the winding reel at a slightly greater peripheral speed than that of the mill rolls, and thereby apply tension to the strip between the winding reel and the mill rolls. Similarly, the drive of the unwinding reel is such as to exert a slight tension on the strip between the unwinding reel and the mill rolls.

Deflector Rolls

In the original installation each of the deflector rolls of the 4-high reversing mill unit was an idler roll and was turned only by frictional force resulting from contact with the strip during a coiling operation. The original installation was modified shortly after operations began, and as modified each deflector roll was motor driven by a low horsepower motor. During a coiling operation the rolls were motor driven in a direction and at a speed which conformed to the direction and speed of the main mill rolls. At other times the rolls were motor driven slowly at idling speed to prevent warping (*ante*, p. 11).

In November, 1951 a disengageable magnetic clutch was incorporated in each of the deflector roll drives. During a coiling operation the magnetic clutch is disengaged and the deflector rolls are not motor driven but are turned only by frictional engagement with the strip as it is wound and unwound from the coiling reels. At all other times the magnetic clutch is engaged and the deflector rolls are motor driven. The deflector rolls are inter-connected through an electrical circuit to the switches controlling the table rolls. When the table roll control switches are actuated to start, stop, accelerate or decelerate the table rolls, the deflector rolls also start, stop, accelerate or decelerate.

An inter-connection through an electrical circuit between the deflector roll drive and the coiling reel controls causes the magnetic clutch of the deflector roll motor to disengage when the Coiler Selector

Switch is placed in the "Normal" position. In this position, used during a coiling operation, the deflector rolls are driven only as a result of frictional engagement with the strip, and a change in the table roll control switches does not affect the deflector rolls.

Roll Tables

The table rolls of the roll table in the immediate vicinity of the 4-high reversing mill unit may be actuated independently of the Mill Master Switch, as is the case when no strip is running in the mill, or may be actuated by the Mill Master Switch during the rolling operation. When actuated independently, these rolls will turn slowly at idling speed. When actuated by tie-in with the Mill Master Switch the direction and speed at which the table rolls turn depend on the direction and speed at which the main mill rolls turn.

Deflector

Each of the deflectors is actuated by a hydraulic cylinder, controlled by a Gate switch on the Assistant Operator's Desk Panel (Drawing A-25). This switch may occupy one of three positions: (1) "South Up", in which position the south deflector is in its raised position to feed the strip into the south coiling reel; (2) "Down", in which position both deflectors are down; and (3) "North Up", in which position the north deflector is in its raised position to feed the strip into the north coiling reel. As originally installed the Operator's desk was fitted with a Gate control (Drawing A-24) and the north deflector was actuated by the Operator. Shortly after commercial operation commenced, however, and the work load of each of the operators was established, the Gate control switch on the Assistant Operator's Desk was tied into the north deflector and both deflectors were actuated by the Assistant Operator.

Water and Steam Sprays

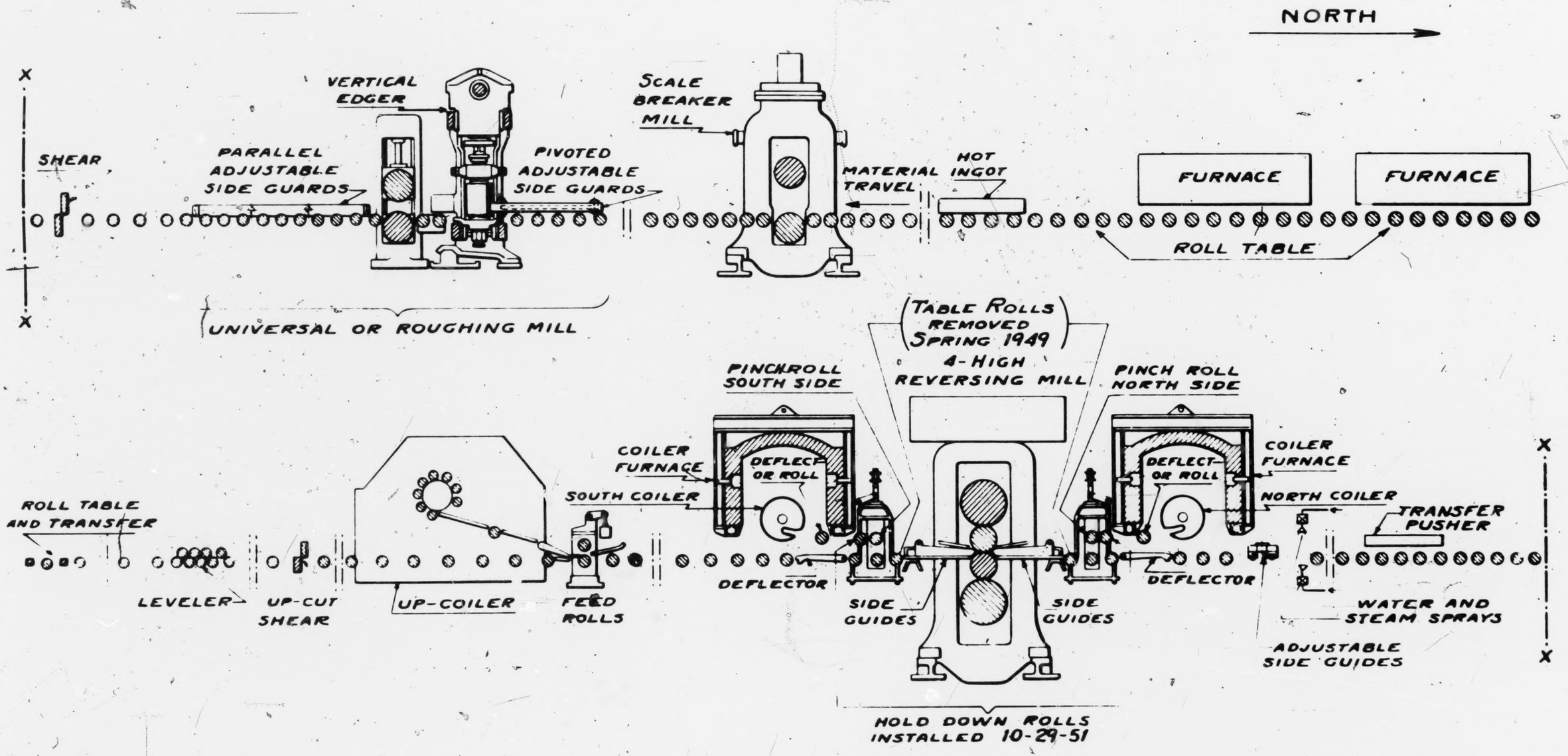
The water and steam spray positioned north of the north coiling reel, and used only as the strip approaches the 4-high mill on the first pass, is actuated by the Water and Steam switches under the control of the Assistant Operator in the south pulpit (Drawing A-25).

EXHIBIT D-6

INDEX OF DRAWINGS

	Drawing No.	*Page*
Diagrammatic Section of Complete Mill	A-1	131b
4-High Reversing Mill Stand & Coilers—Plan View	A-2	132b
4-High Reversing Mill Stand & Coilers—Modified Installation —Vertical Section	A-3	133b
Vertical Section at Pinch Roll & Coiler—Original Installation	A-4	134b
Vertical Section at Pinch Roll & Coiler—Modified Installation	A-5	135b
Deflector & Pinch Roll Assembly—Original Installation	A-6	136b
Deflector & Pinch Roll Assembly—Modified Installation	A-7	137b
Pinch Roll Operation—Original Installation	A-8	138b
Pinch Roll & Auxiliary Roll Arrangement—Modified Installation	A-9	139b
Side Guide Assembly	A-10	140b
Operational Drawing 1—Original Installation	A-11	141b
Operational Drawing 2—Original Installation	A-12	142b
Operational Drawing 3—Original Installation	A-13	143b
Operational Drawing 4—Original Installation	A-14	144b
Operational Drawing 5—Original Installation	A-15	145b
Operational Drawing 6—Original Installation	A-16	146b
Operational Drawing 7—Modified Installation	A-17	147b
Operational Drawing 8—Modified Installation	A-18	148b
Operational Drawing 9—Modified Installation	A-19	149b
Operational Drawing 10—Modified Installation	A-20	150b
Operational Drawing 11—Modified Installation	A-21	151b
Operational Drawing 12—Modified Installation	A-22	152b
Side Guide Positions—Diagrammatically Illustrated	A-23	153b
4-High Reversing Mill Operator's Desk Panel	A-24	154b
4-High Reversing Mill Assistant Operator's Desk Panel	A-25	155b

CRUCIBLE HOT STRIP MILL
DIAGRAMMATIC SECTION OF COMPLETE MILL

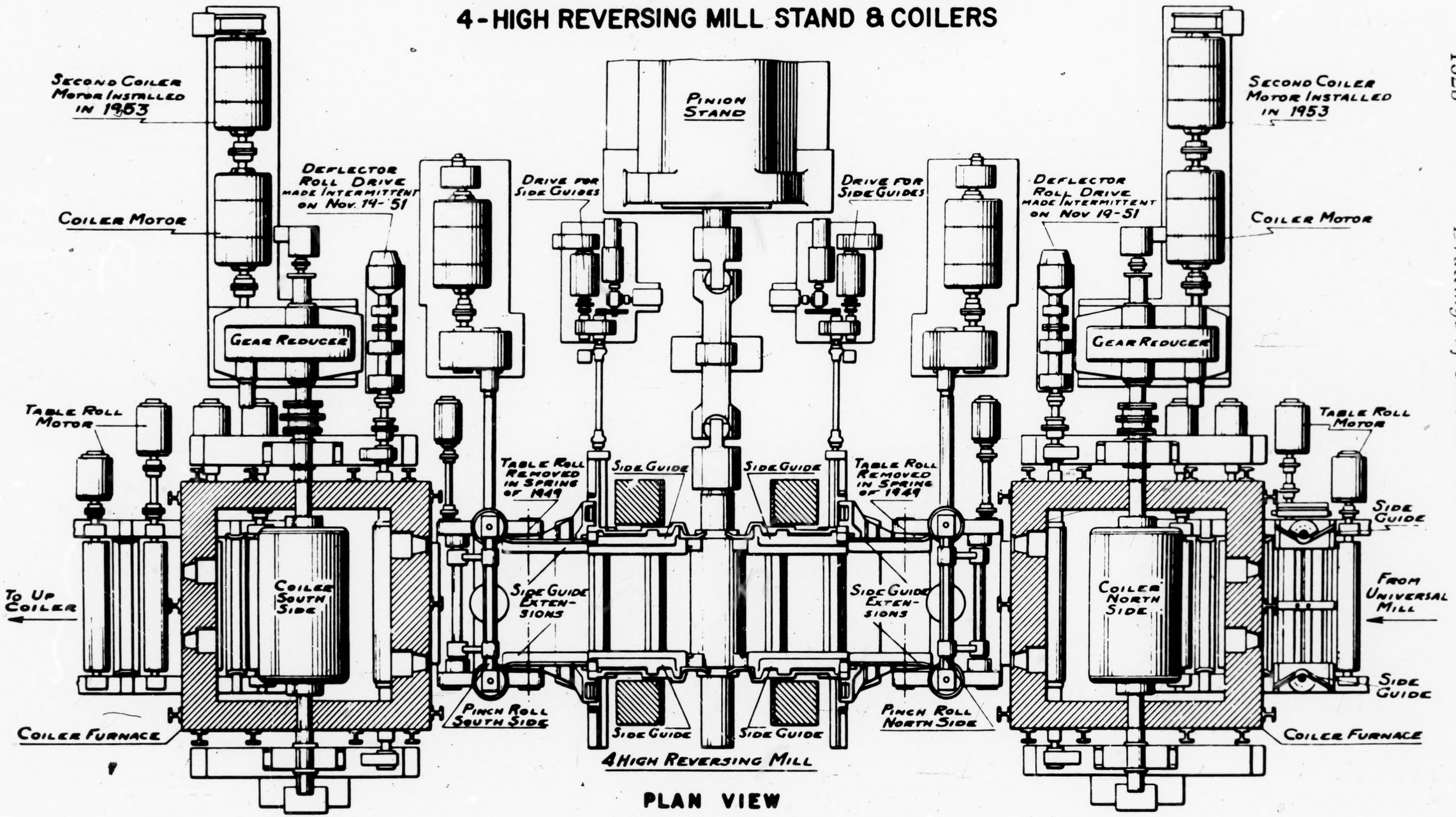


Drawings of Crucible Mill

131b

CRUCIBLE HOT STRIP MILL

4-HIGH REVERSING MILL STAND & COILERS

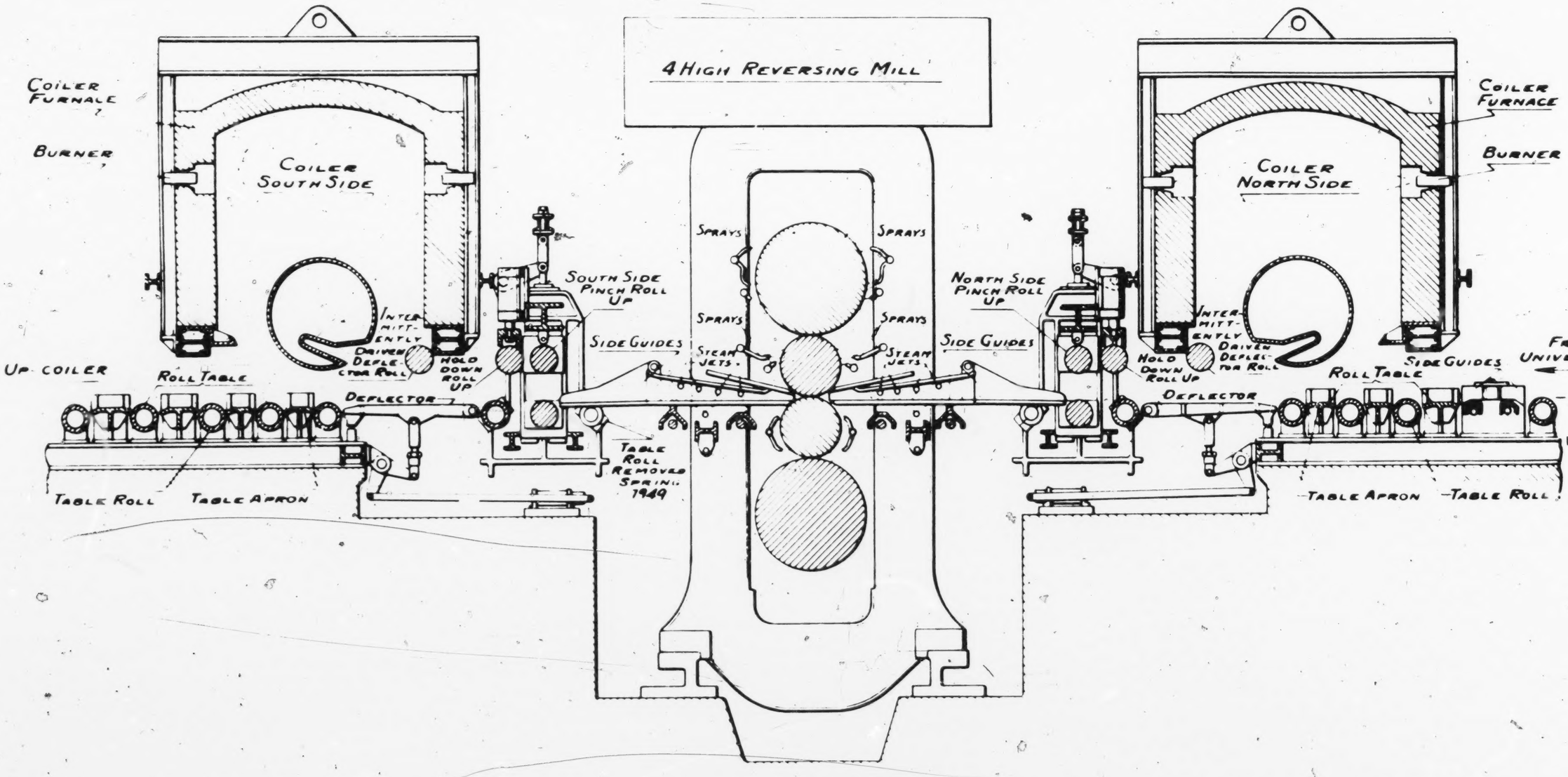


PLAN VIEW

CRUCIBLE HOT STRIP MILL

4-HIGH REVERSING MILL STAND & COILERS

MODIFIED INSTALLATION



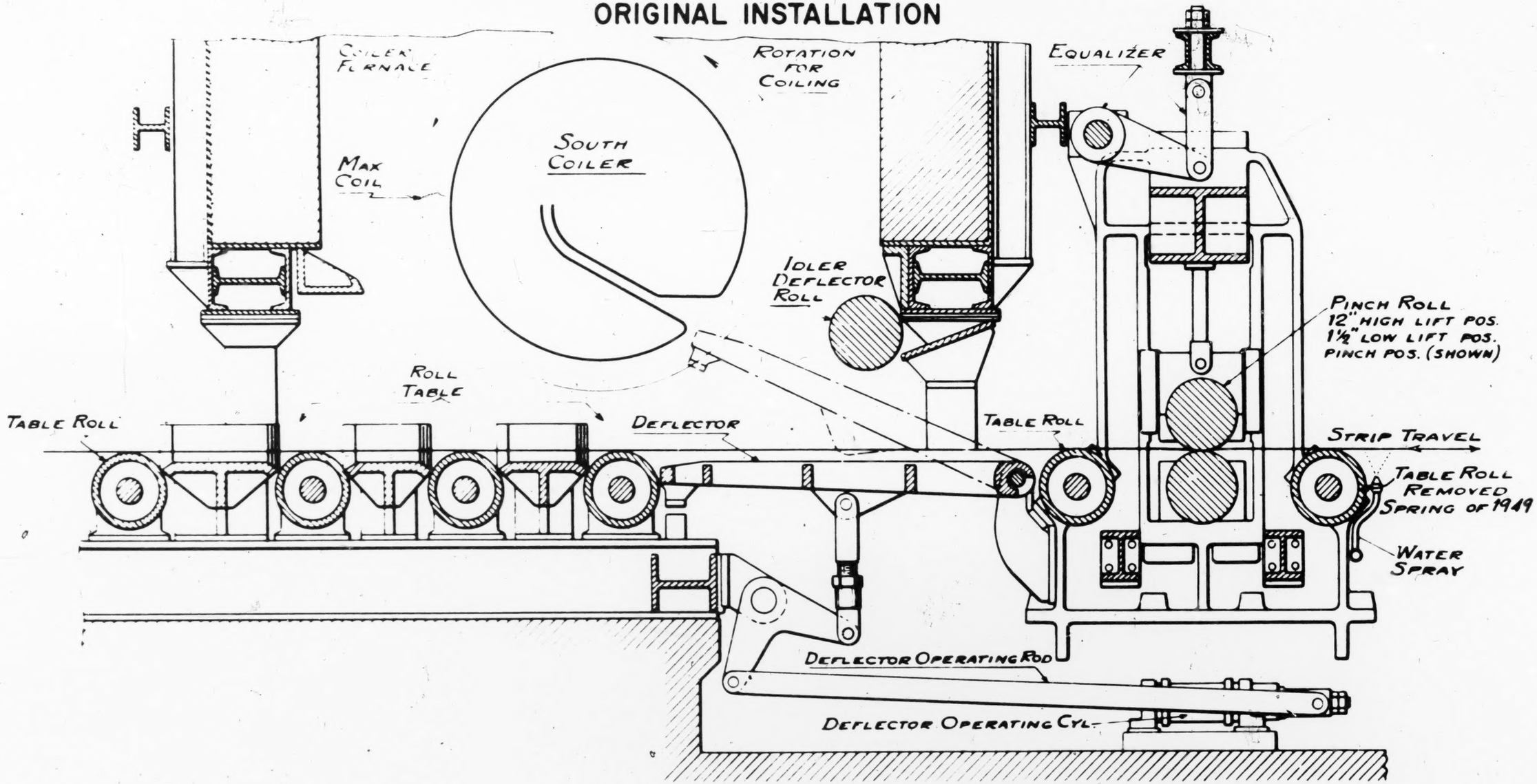
VERTICAL SECTION

Drawings of Crucible Mill 133b

CRUCIBLE HOT STRIP MILL

VERTICAL SECTION AT PINCH ROLL & COILER

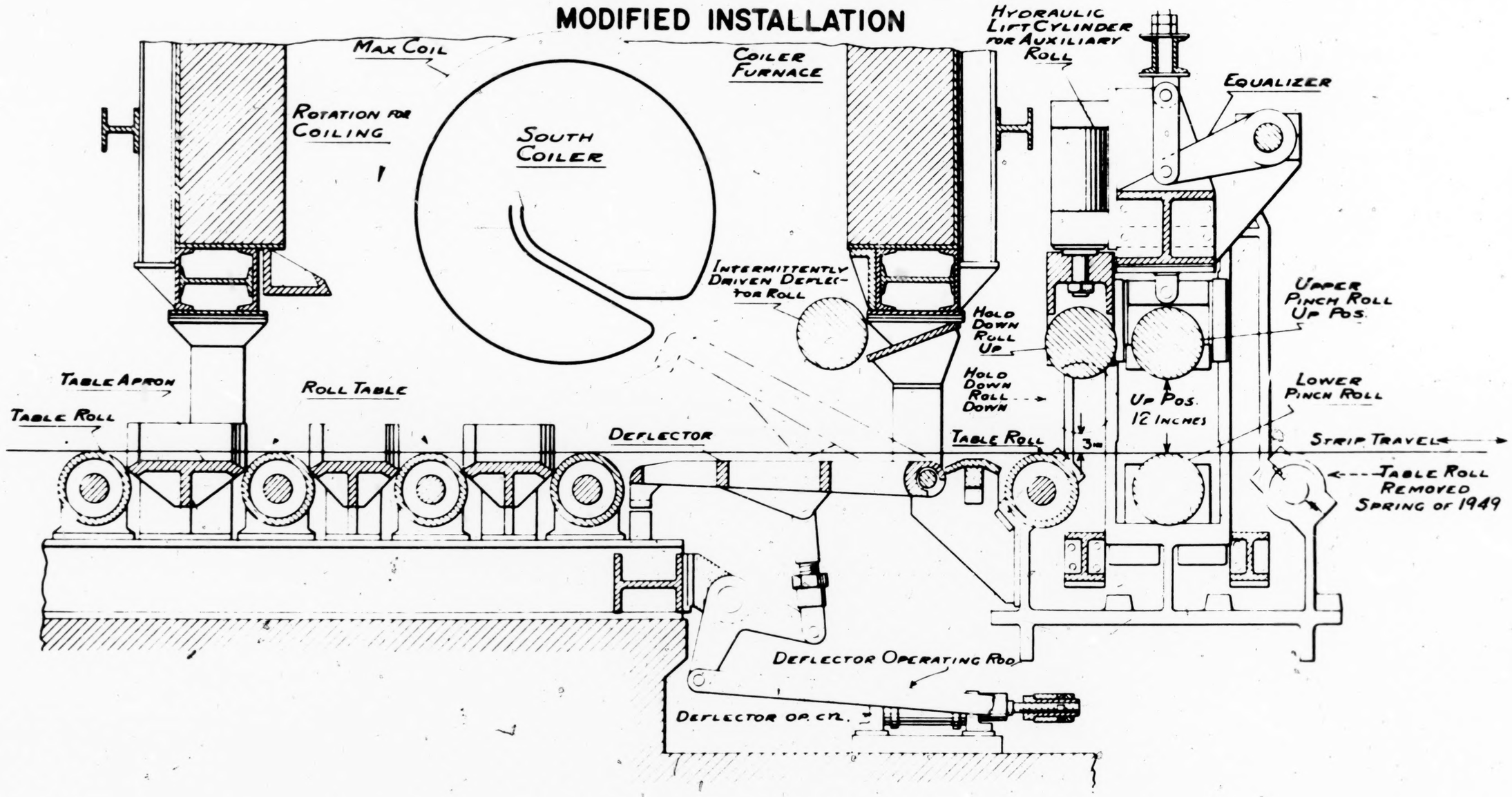
ORIGINAL INSTALLATION



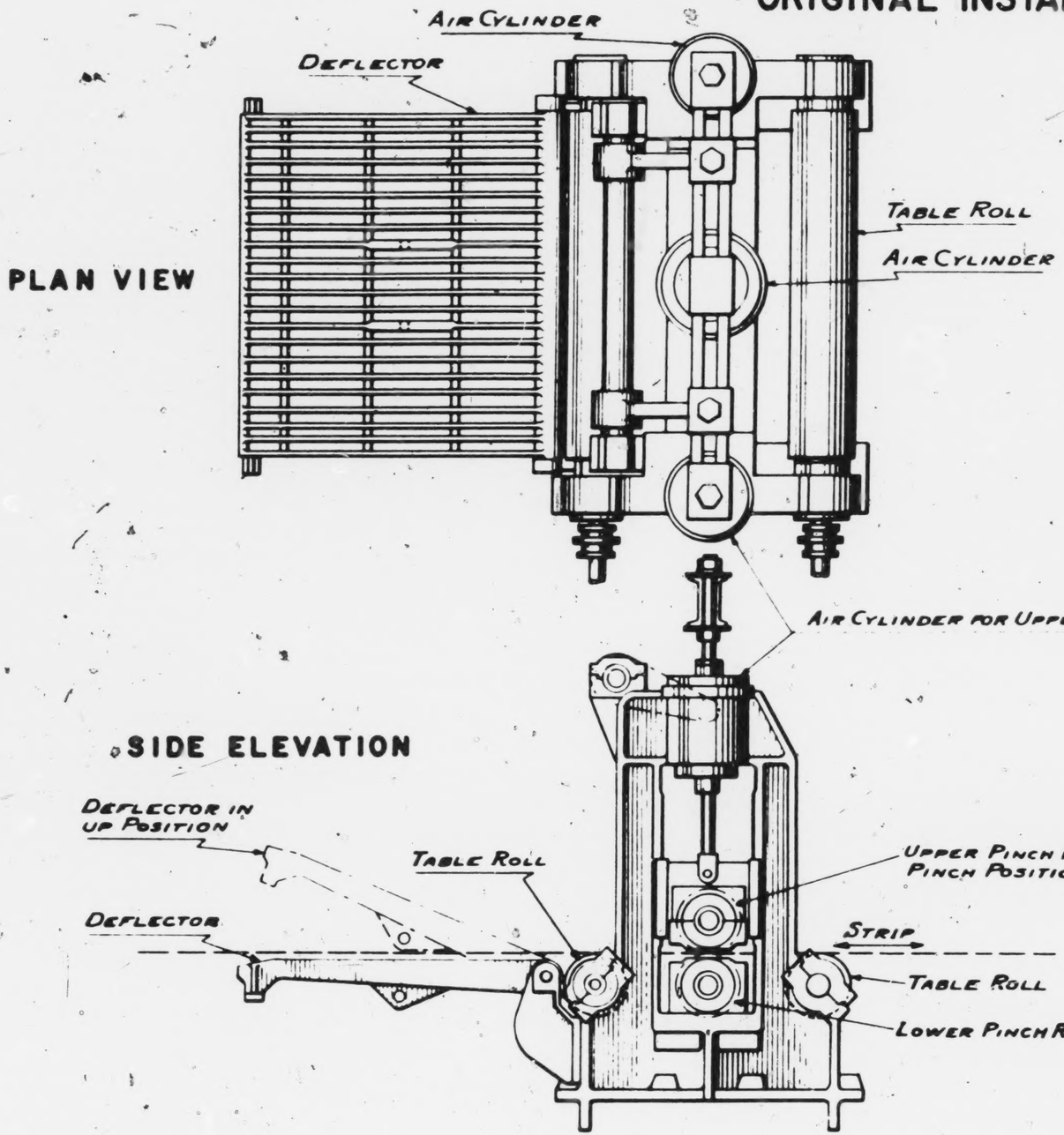
CRUCIBLE HOT STRIP MILL

VERTICAL SECTION AT PINCH ROLL & COILER

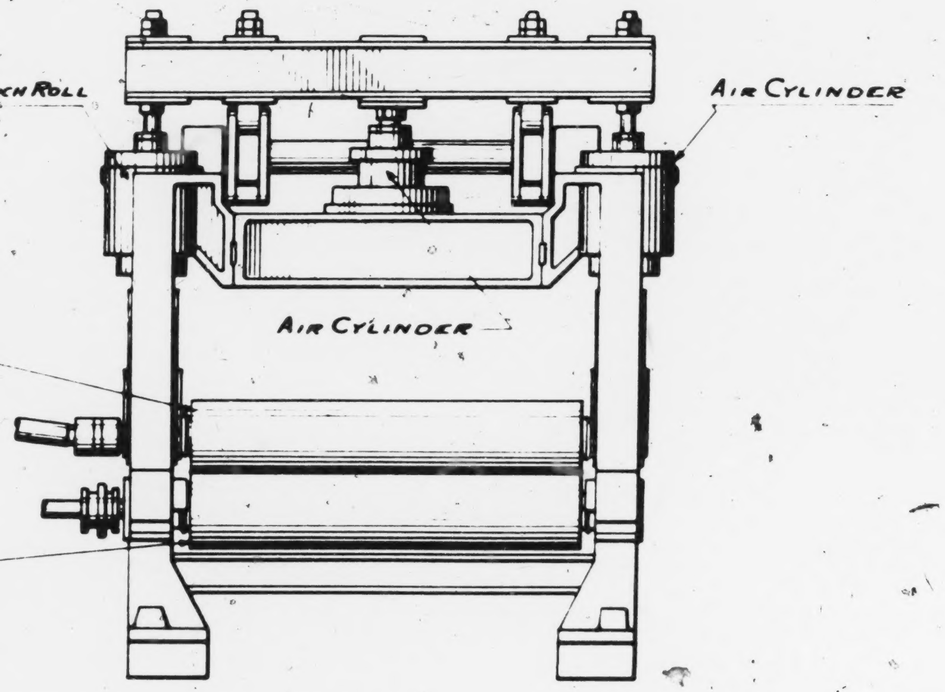
MODIFIED INSTALLATION



CRUCIBLE HOT STRIP MILL
ORIGINAL INSTALLATION



DEFLECTOR AND PINCH ROLL ASSEMBLY

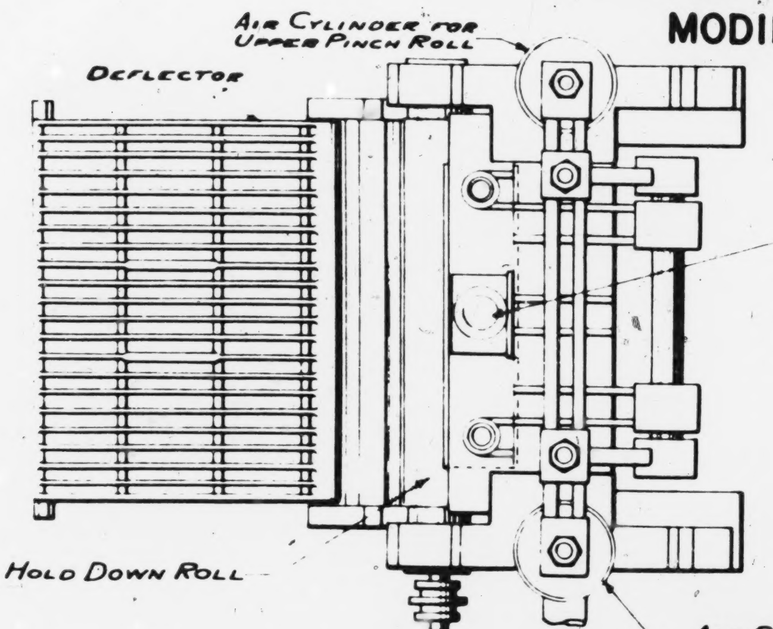


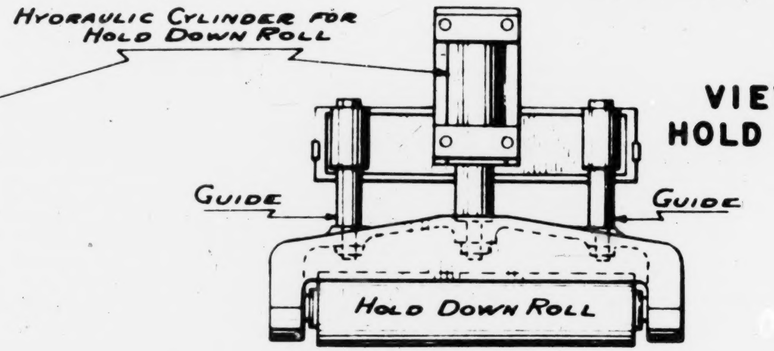
CRUCIBLE HOT STRIP MILL

MODIFIED INSTALLATION

DEFLECTOR AND PINCH ROLL ASSEMBLY

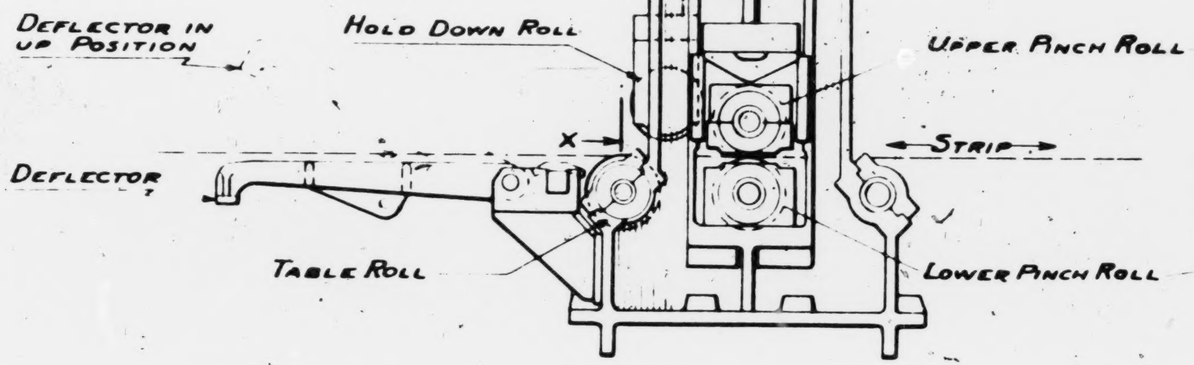
PLAN VIEW

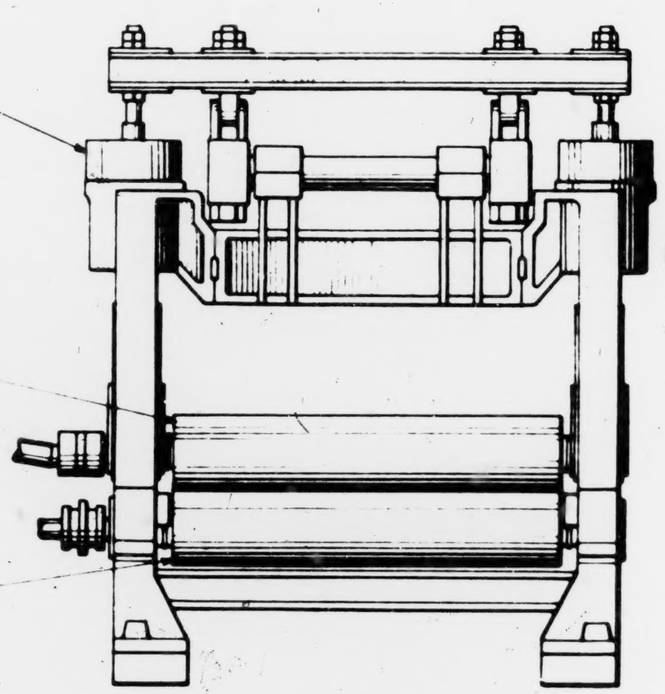




VIEW X-X
HOLD DOWN ROLL

SIDE ELEVATION



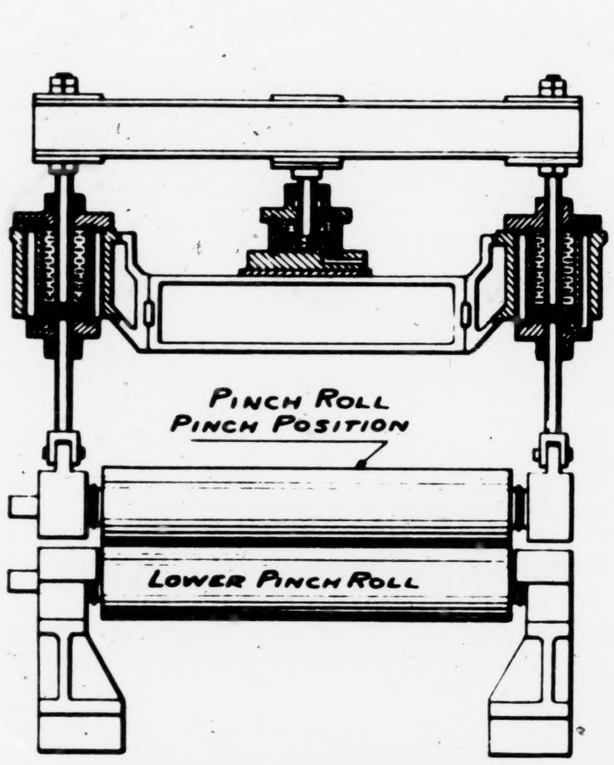


FRONT ELEV.

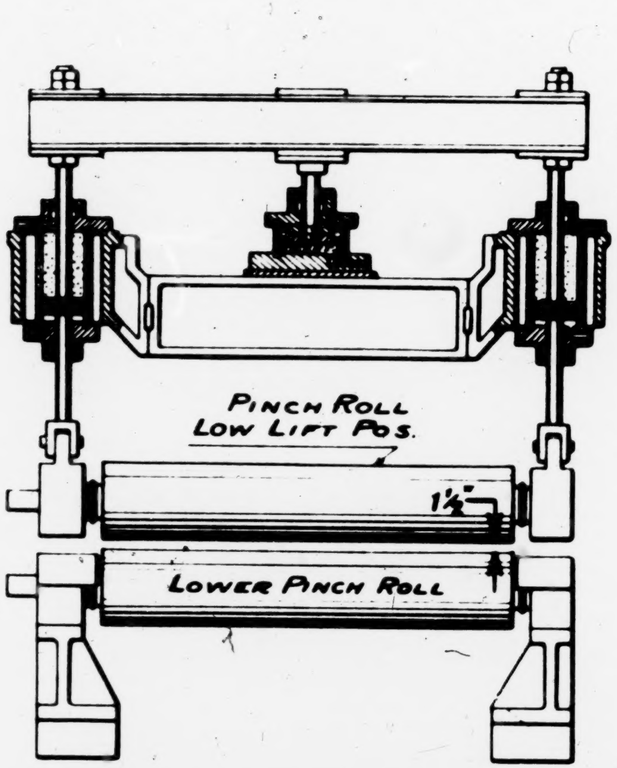
CRUCIBLE HOT STRIP MILL

PINCH ROLL OPERATION

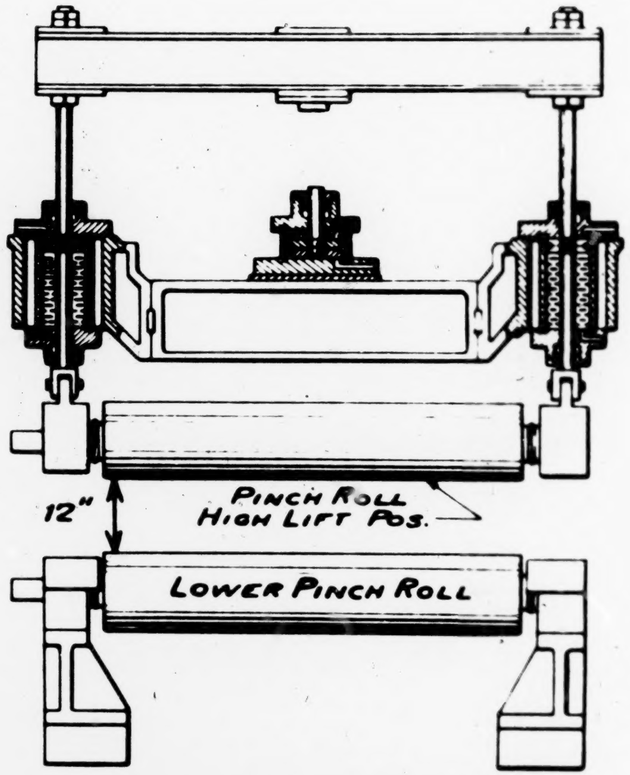
ORIGINAL INSTALLATION



PINCH POSITION



LOW LIFT POSITION



HIGH LIFT POSITION

LEGEND

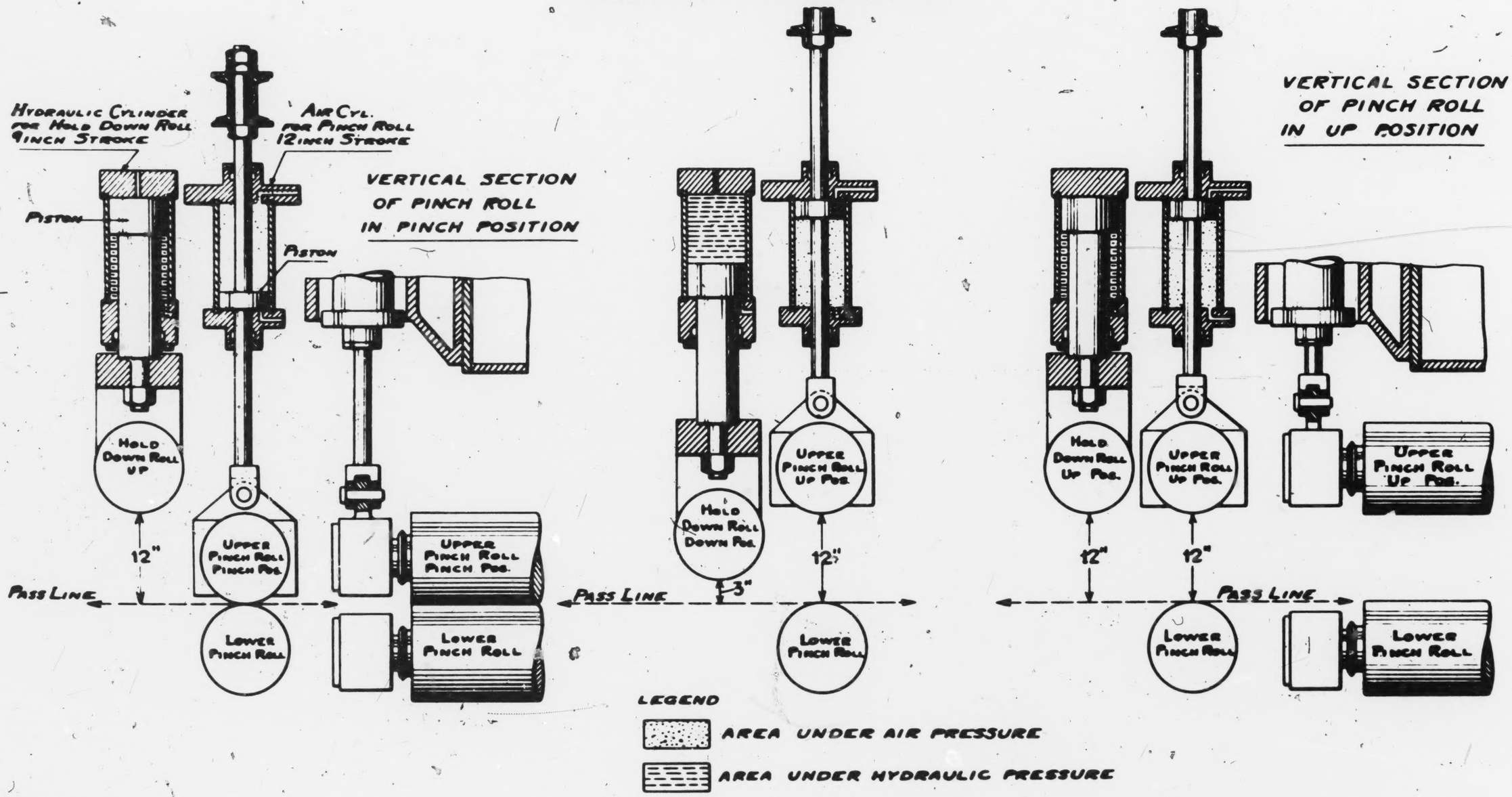
AREA UNDER CONSTANT AIR PRESSURE

AREA AIR LOCKED (CUSHIONED)

CRUCIBLE HOT STRIP MILL

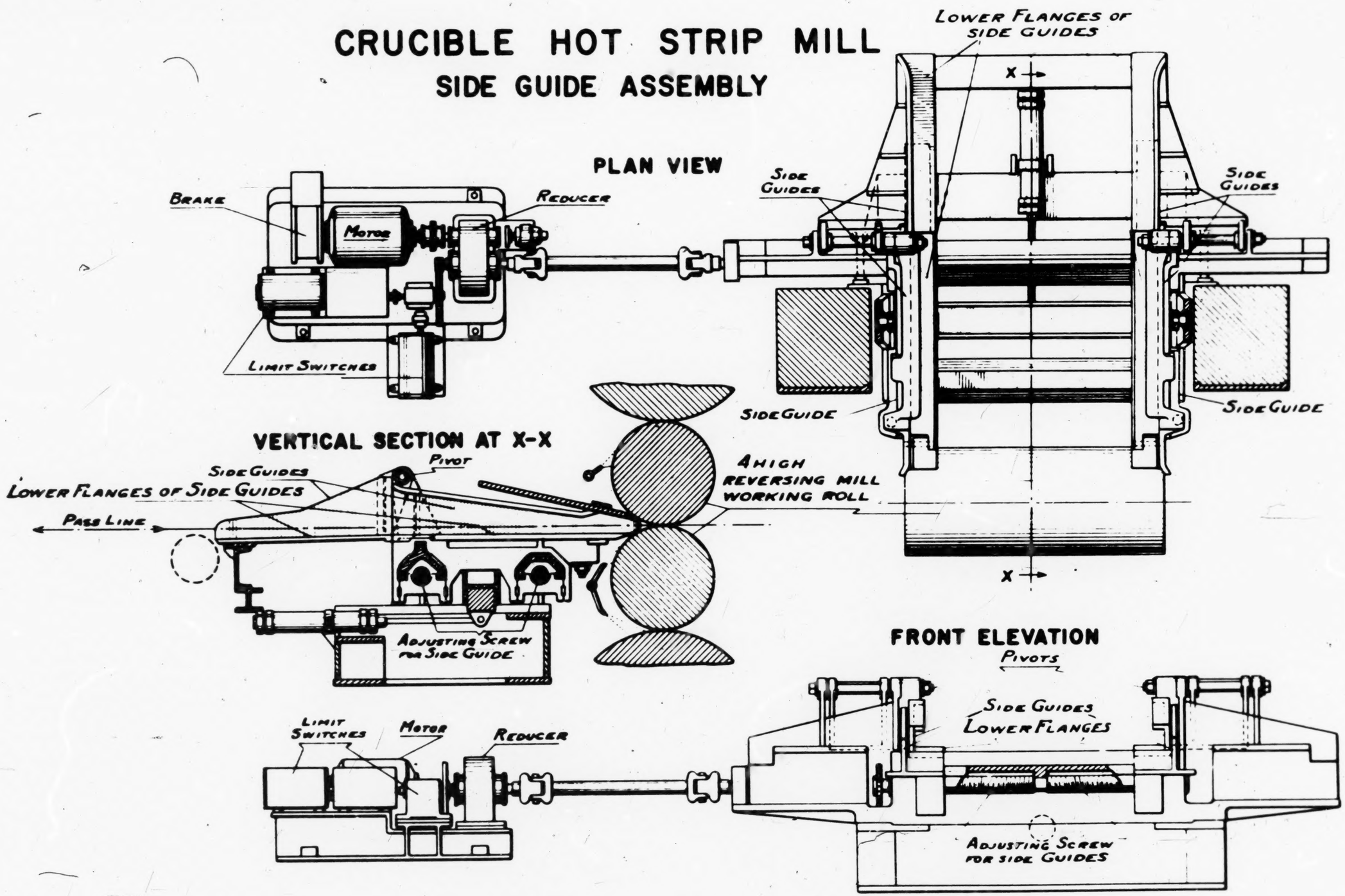
PINCH ROLL & AUXILIARY ROLL ARRANGEMENT

MODIFIED INSTALLATION



CRUCIBLE HOT STRIP MILL

SIDE GUIDE ASSEMBLY



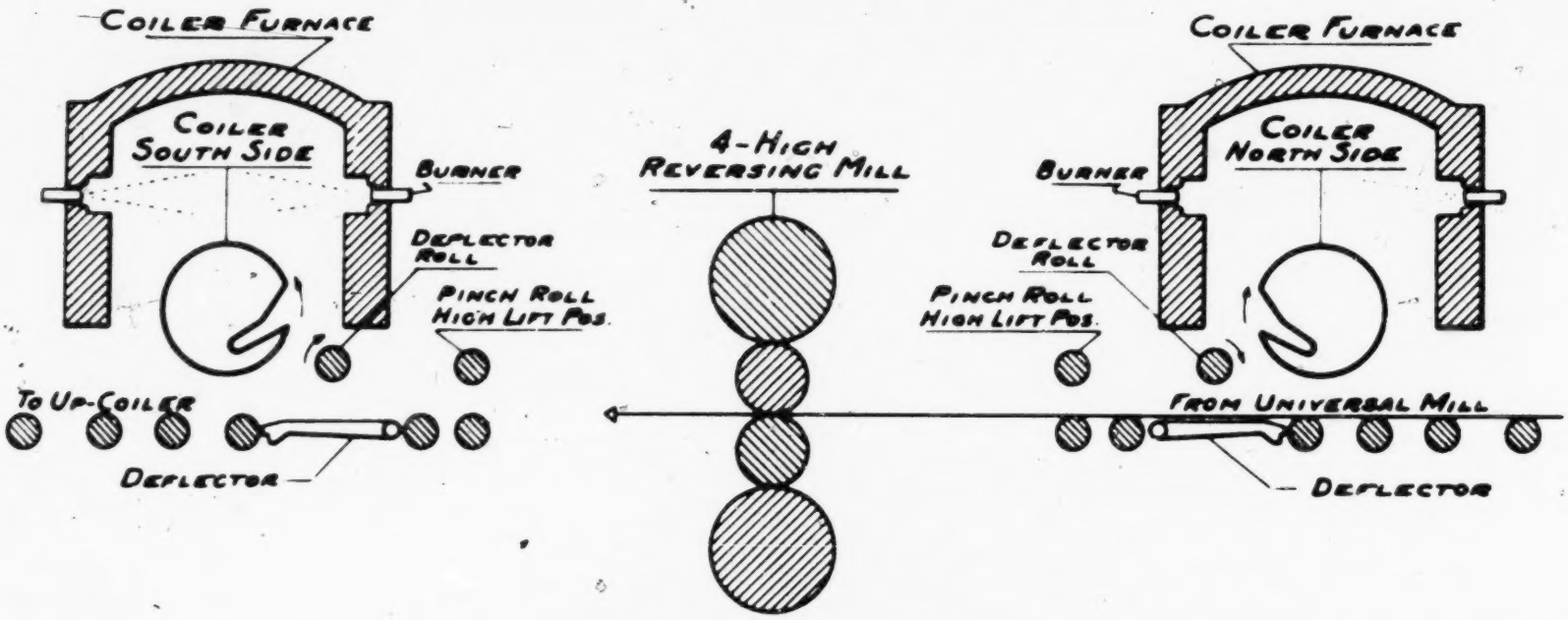
A 11

CRUCIBLE HOT STRIP MILL

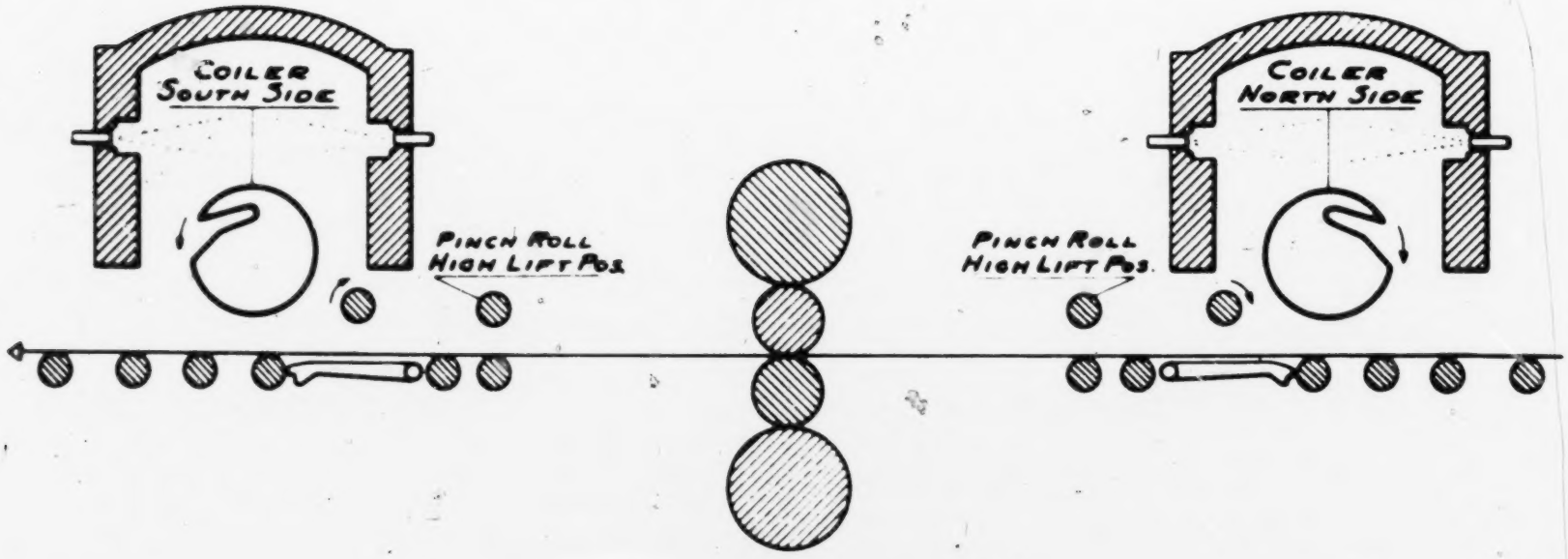
OPERATIONAL DRAWING NO. 1

NORTH →

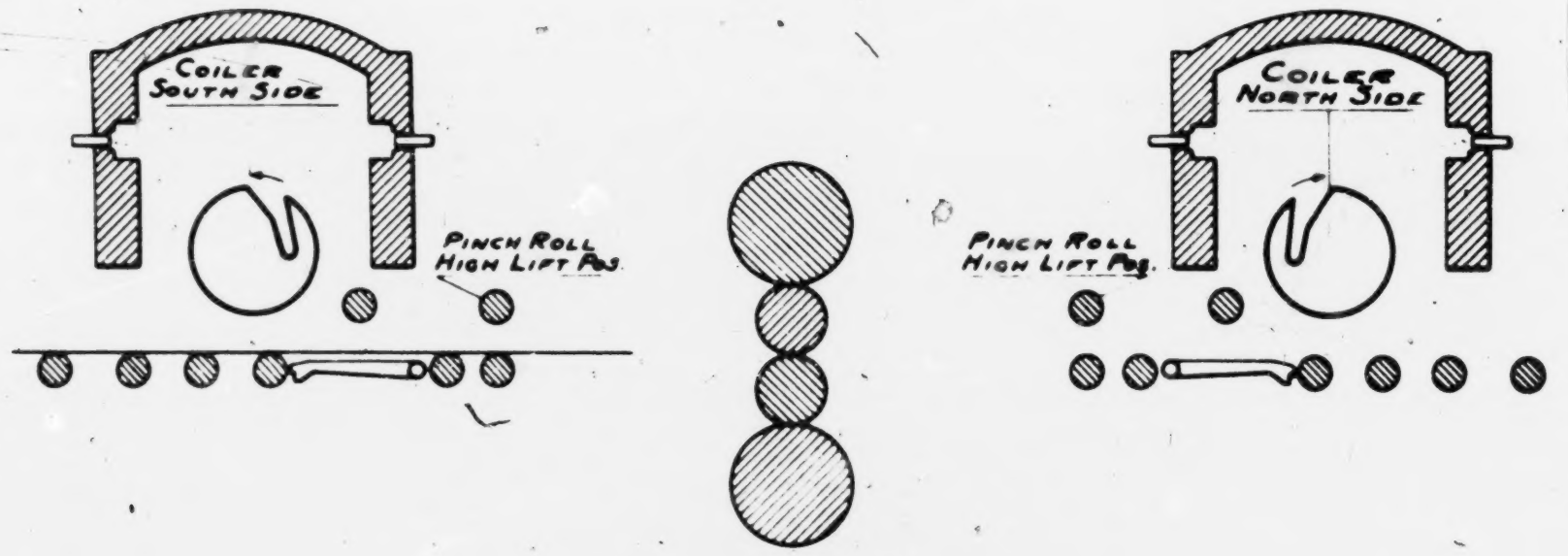
ORIGINAL INSTALLATION



FIRST PASS STARTED



FIRST PASS ROLLING



FIRST PASS COMPLETED

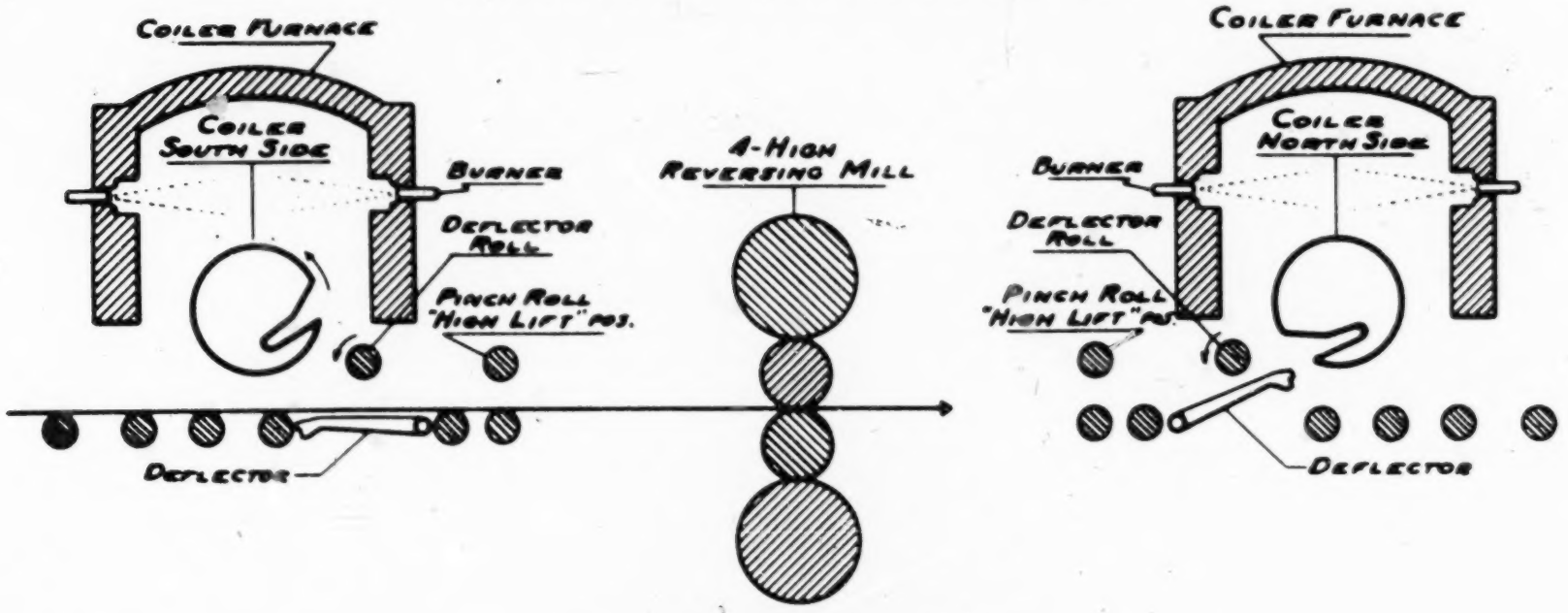
A 12

CRUCIBLE HOT STRIP MILL

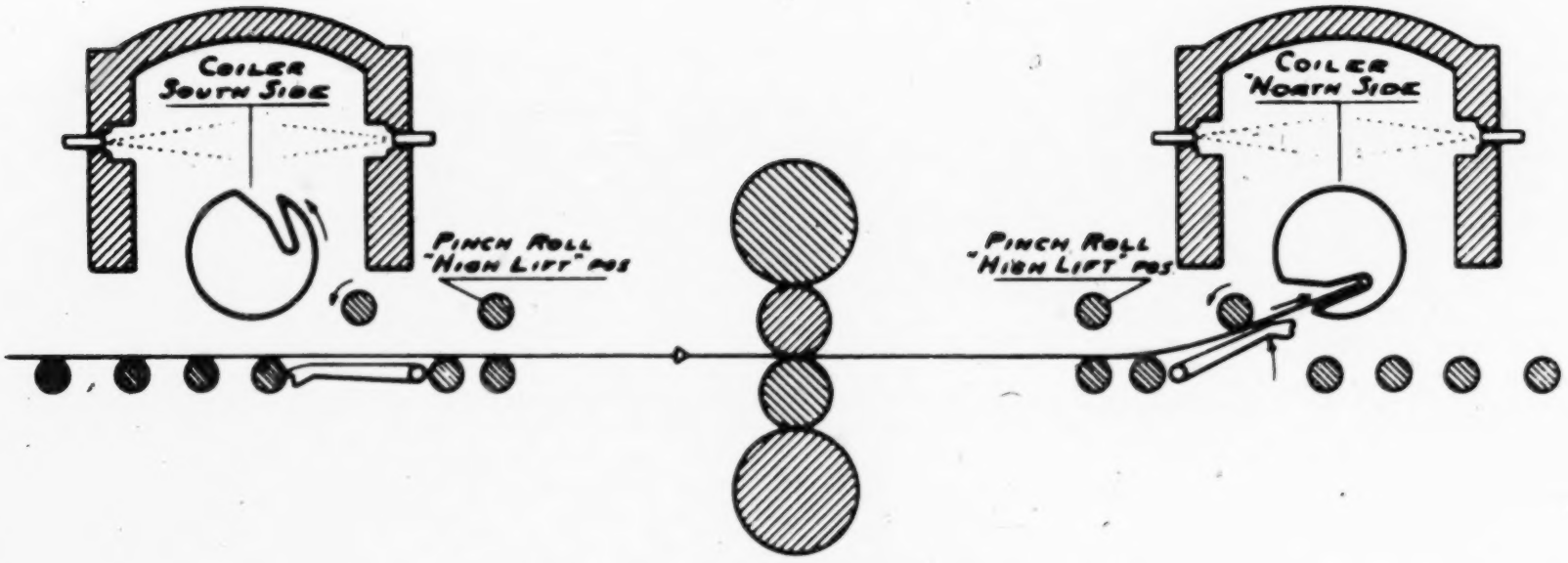
OPERATIONAL DRAWING NO. 2

NORTH →

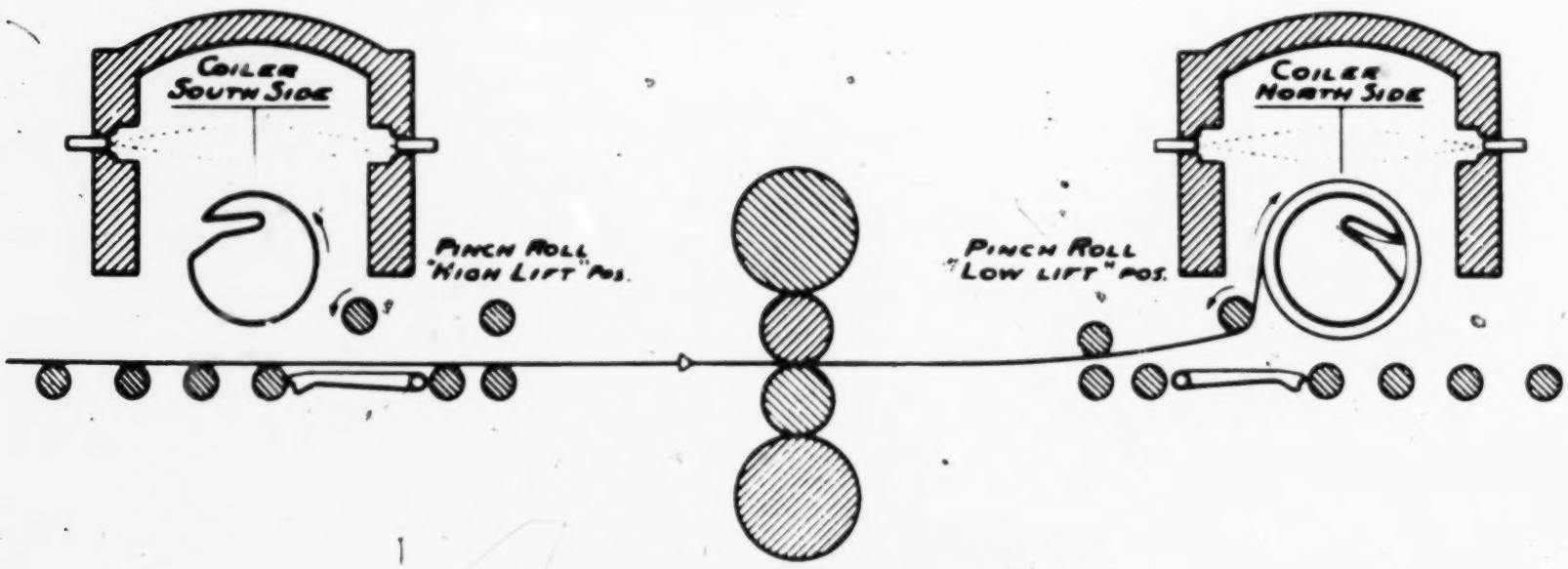
ORIGINAL INSTALLATION



SECOND PASS STARTED



SECOND PASS – STRIP ENTERING COILER ON NORTH SIDE



SECOND PASS DURING ROLLING.

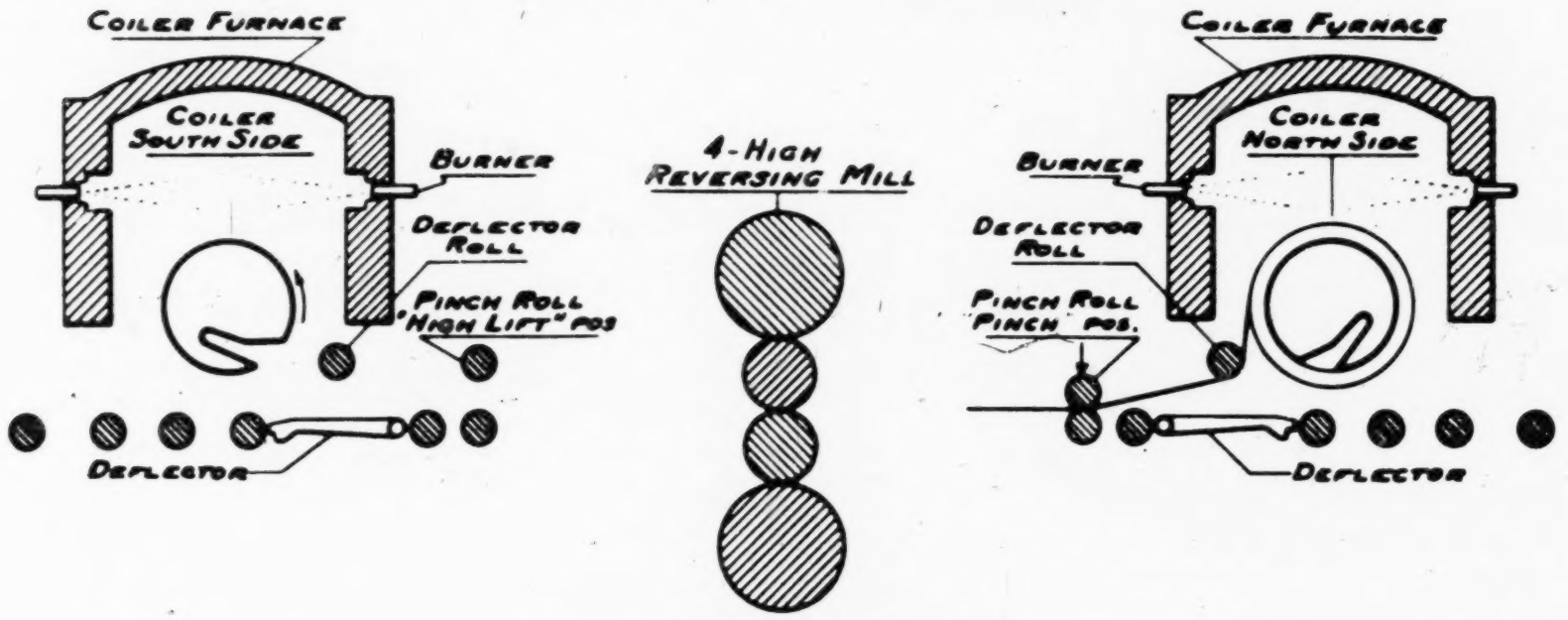
A 13

CRUCIBLE HOT STRIP MILL

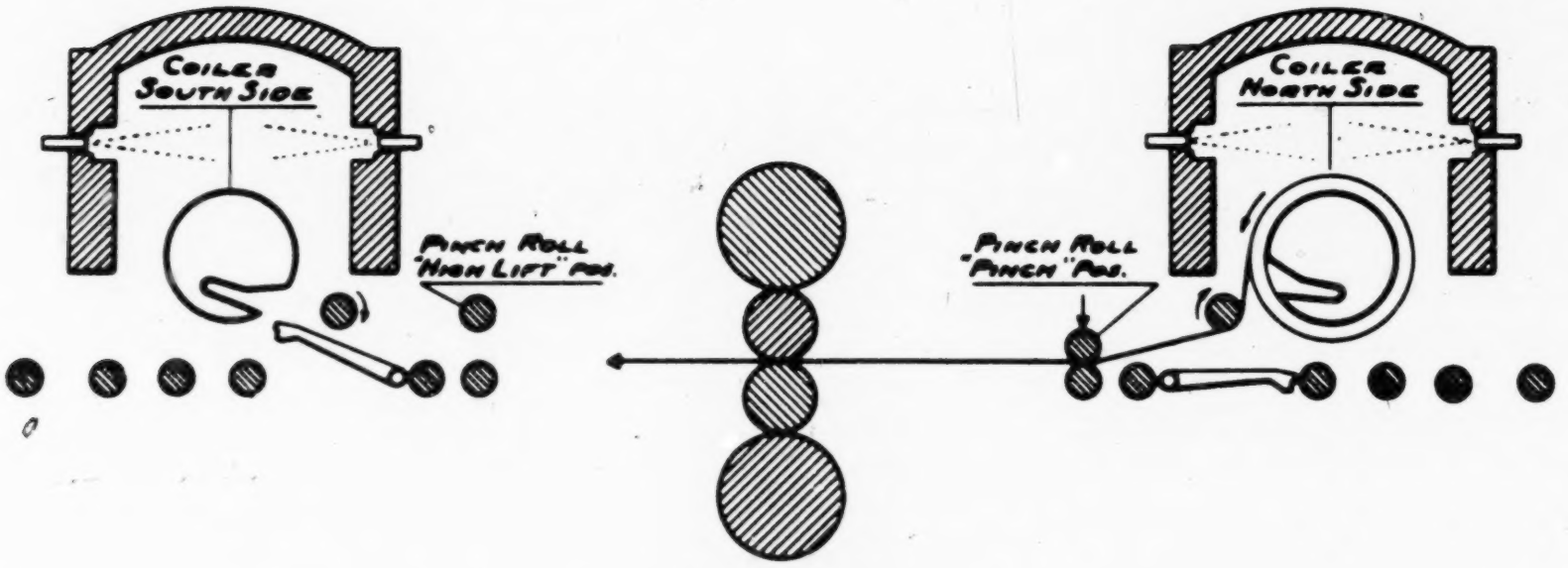
OPERATIONAL DRAWING NO. 3

NORTH →

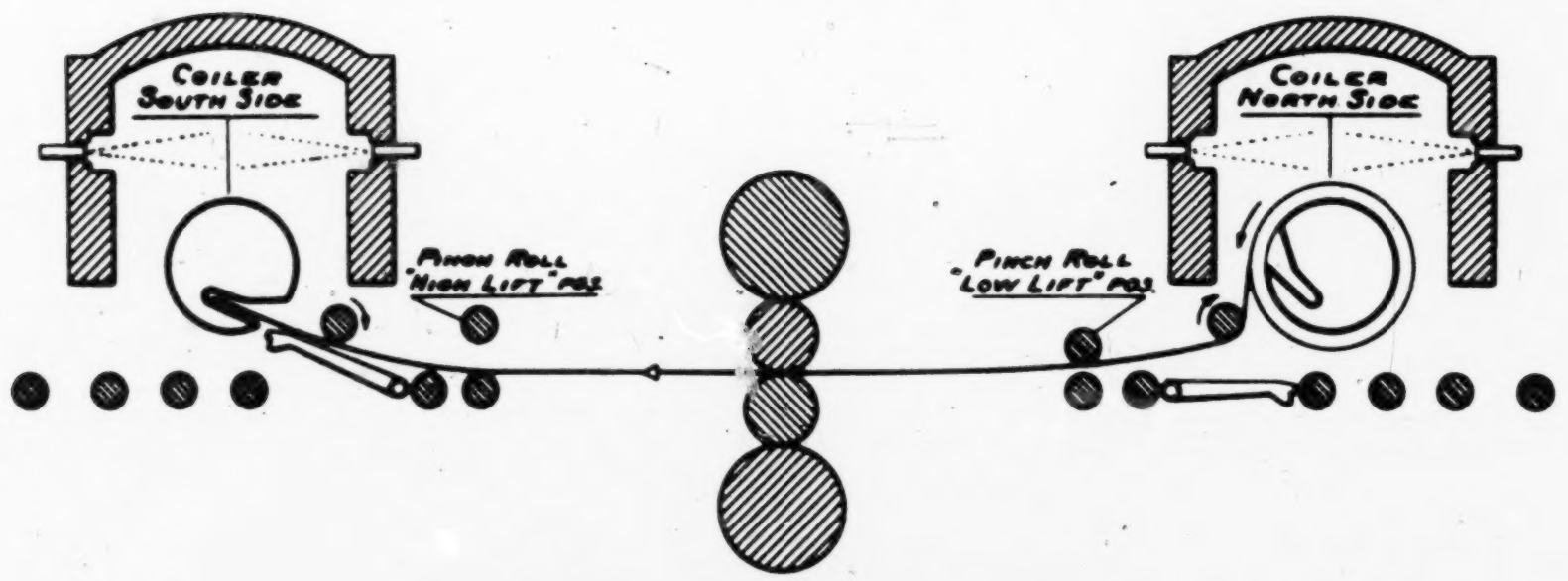
ORIGINAL INSTALLATION



SECOND PASS COMPLETED



THIRD PASS STARTED



THIRD PASS ENTERING SOUTH COILER

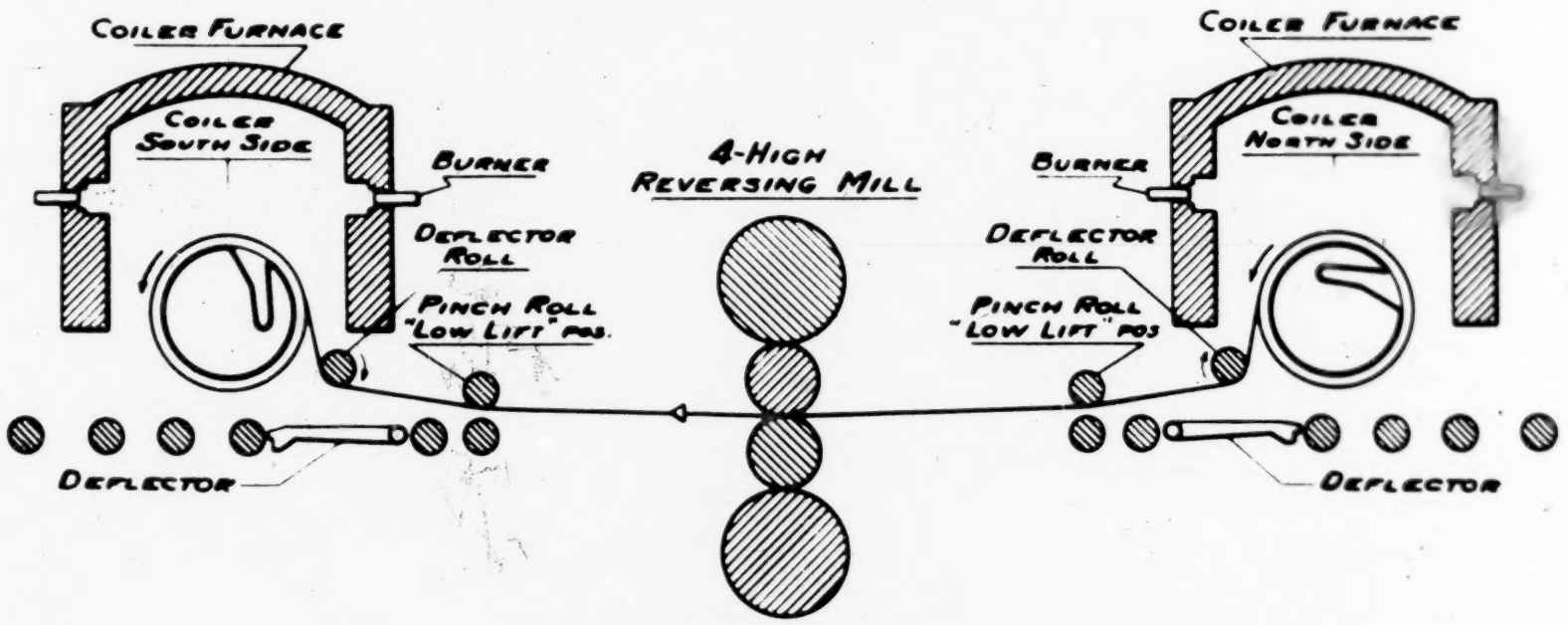
A 14

CRUCIBLE HOT STRIP MILL

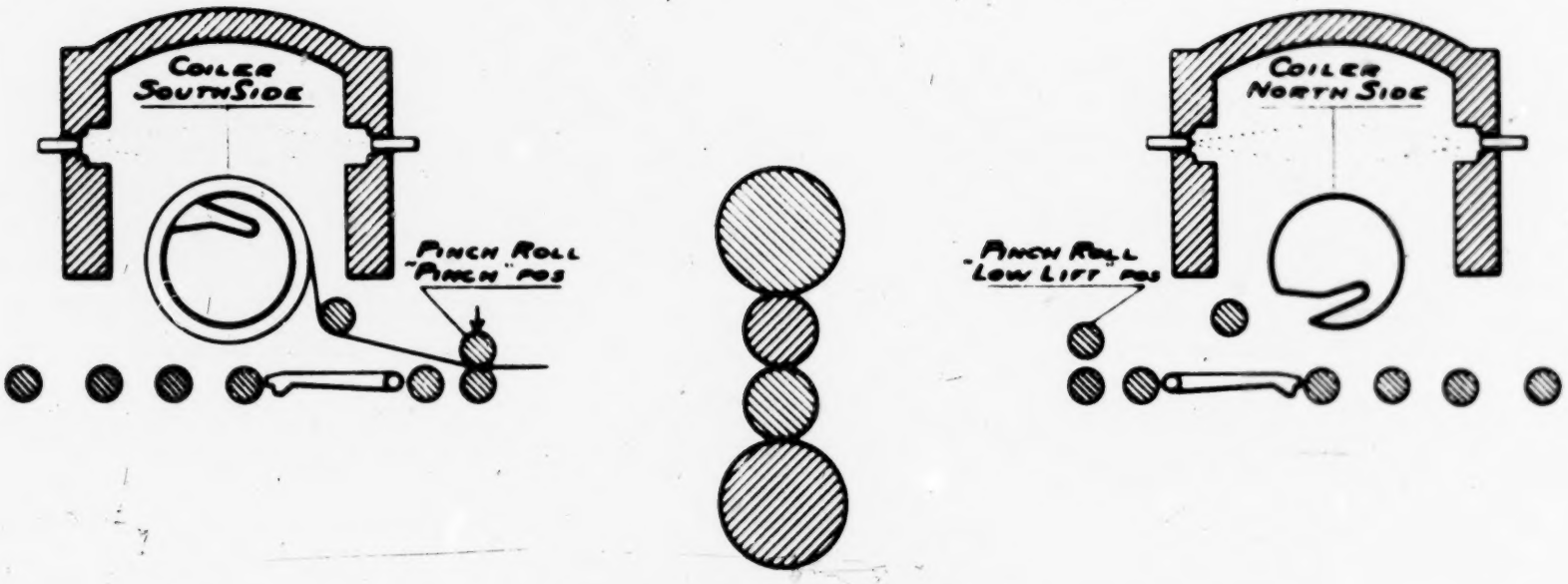
OPERATIONAL DRAWING NO. 4

NORTH →

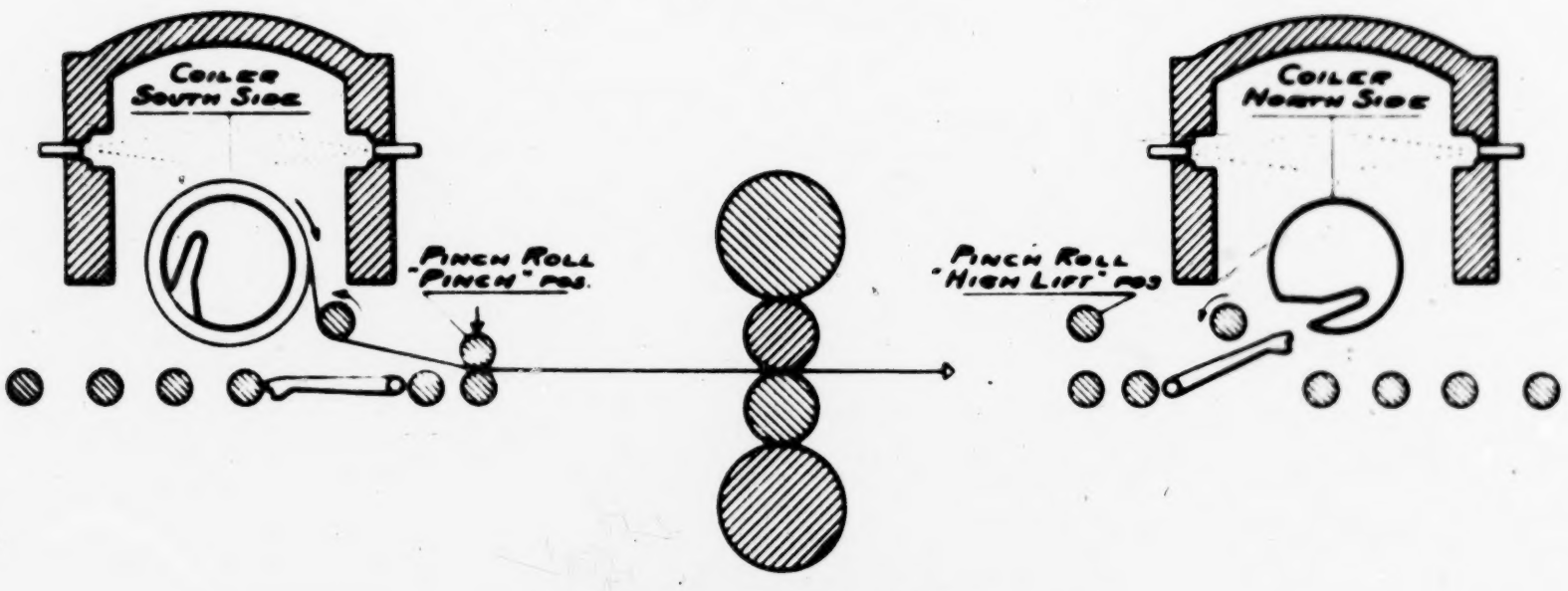
ORIGINAL INSTALLATION



THIRD PASS ROLLING



THIRD PASS COMPLETED



FOURTH PASS STARTED

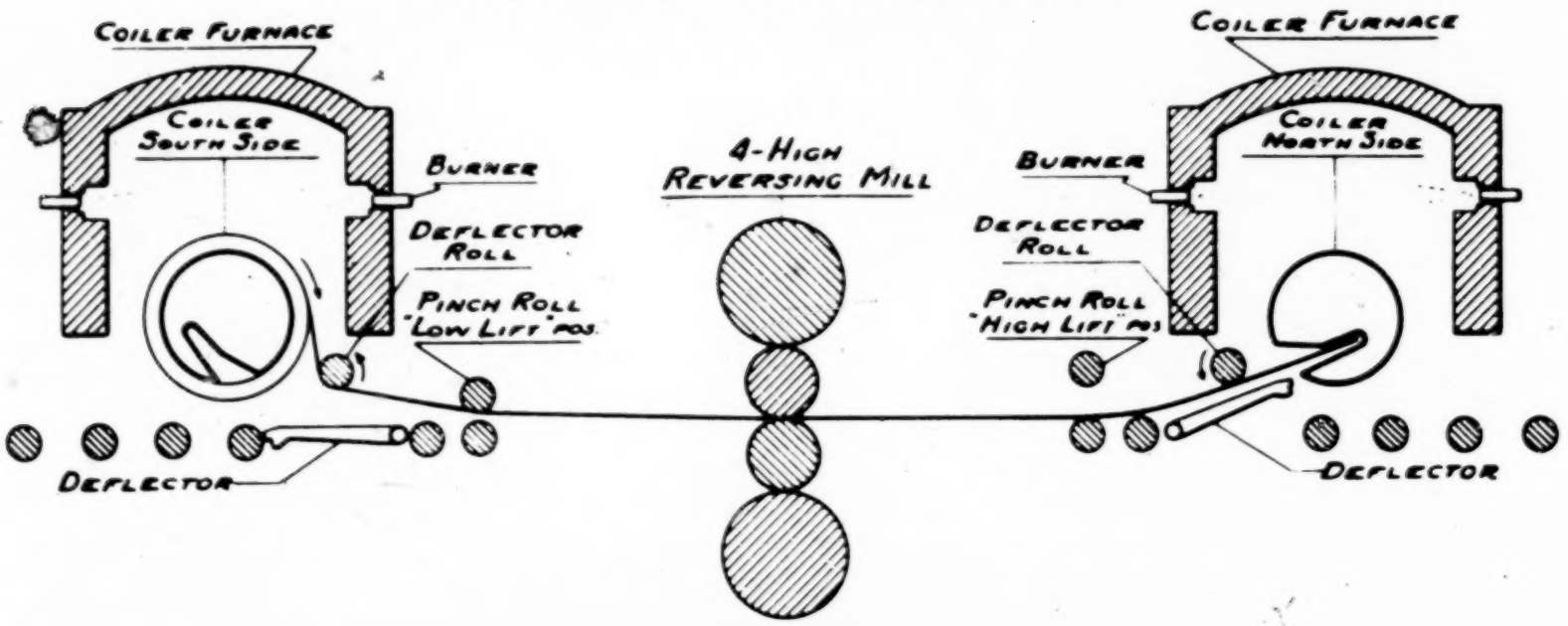
A15

CRUCIBLE HOT STRIP MILL

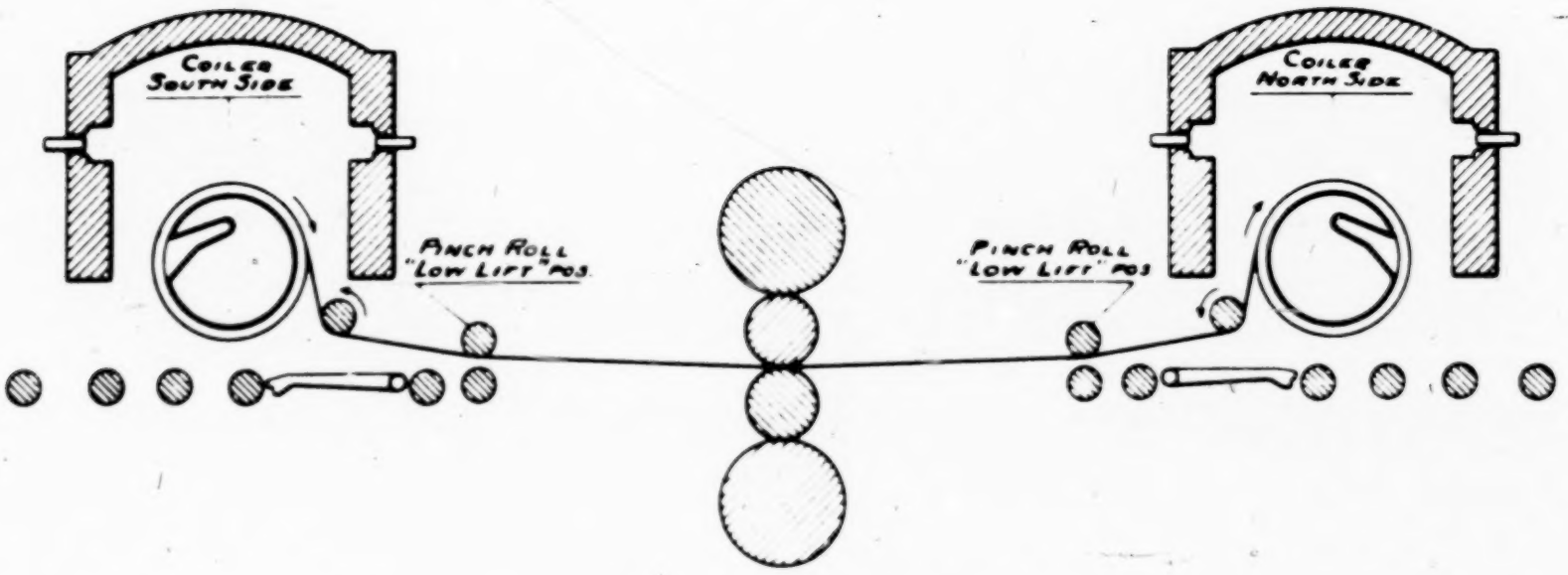
OPERATIONAL DRAWING NO. 5

NORTH →

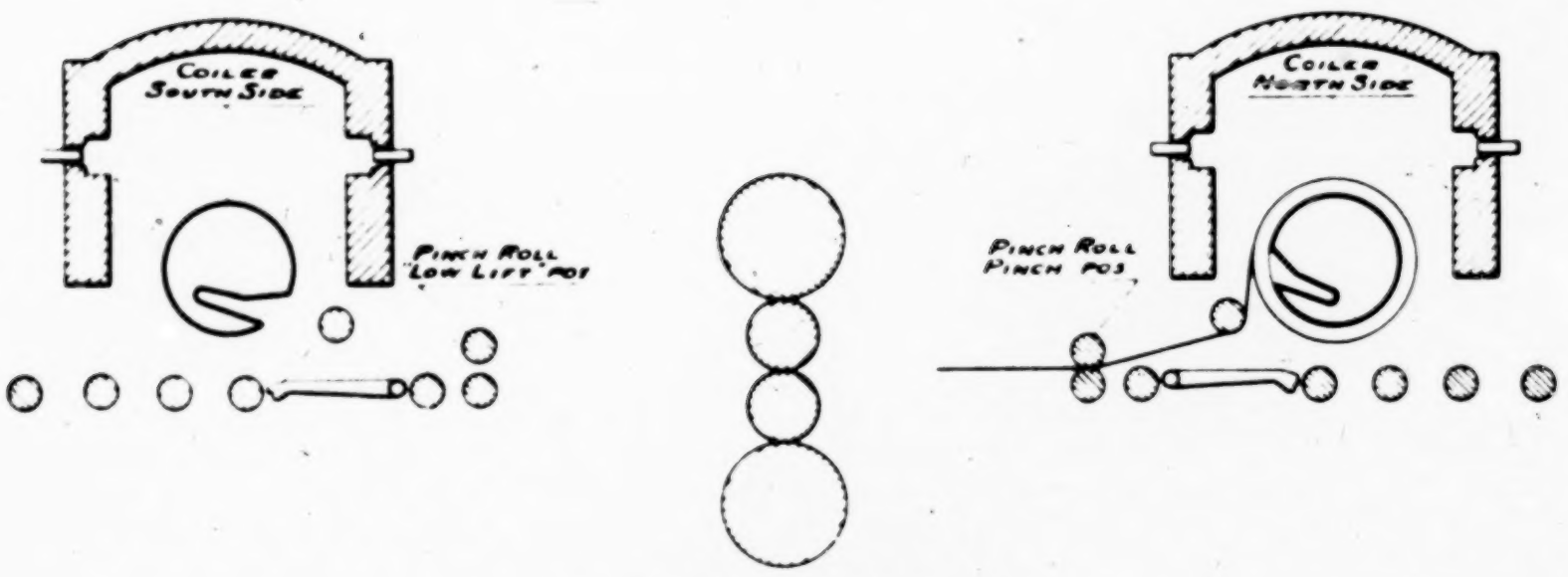
ORIGINAL INSTALLATION



FOURTH PASS ENTERING NORTH COILER



FOURTH PASS ROLLING



FOURTH PASS COMPLETED

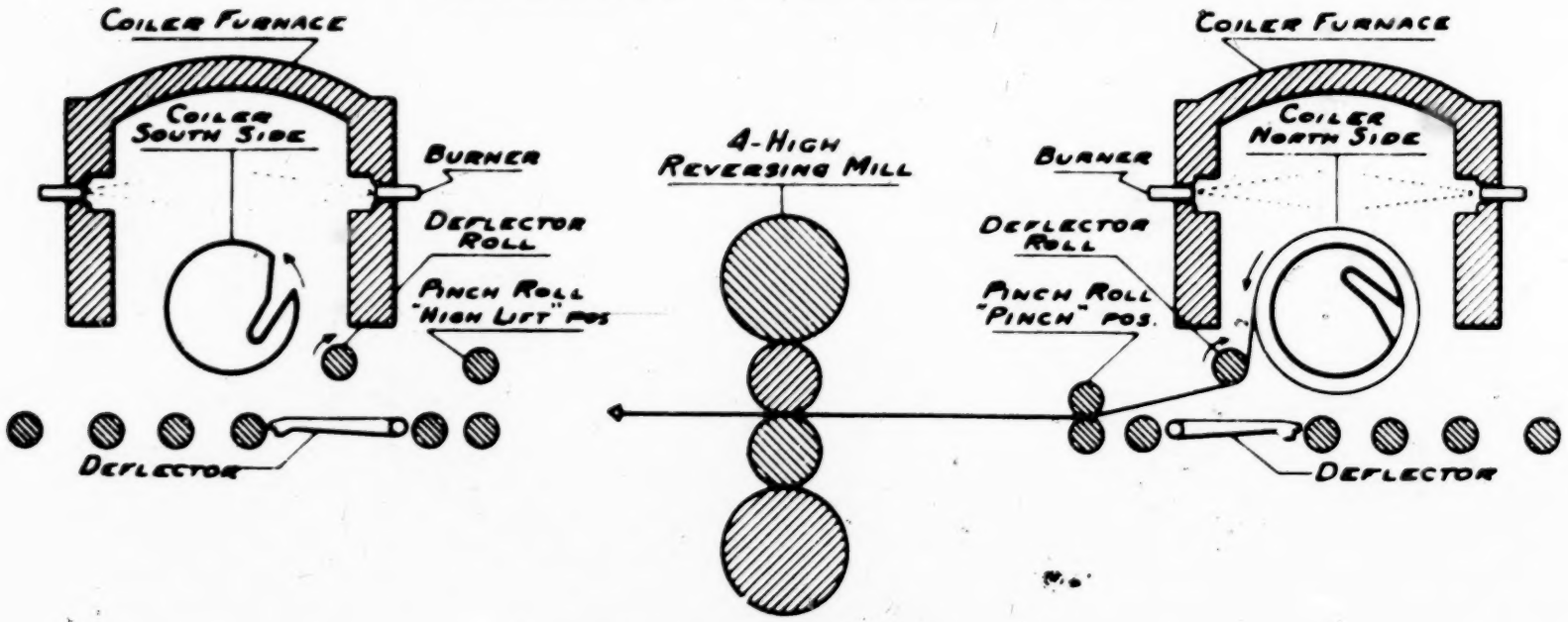
A16

CRUCIBLE HOT STRIP MILL

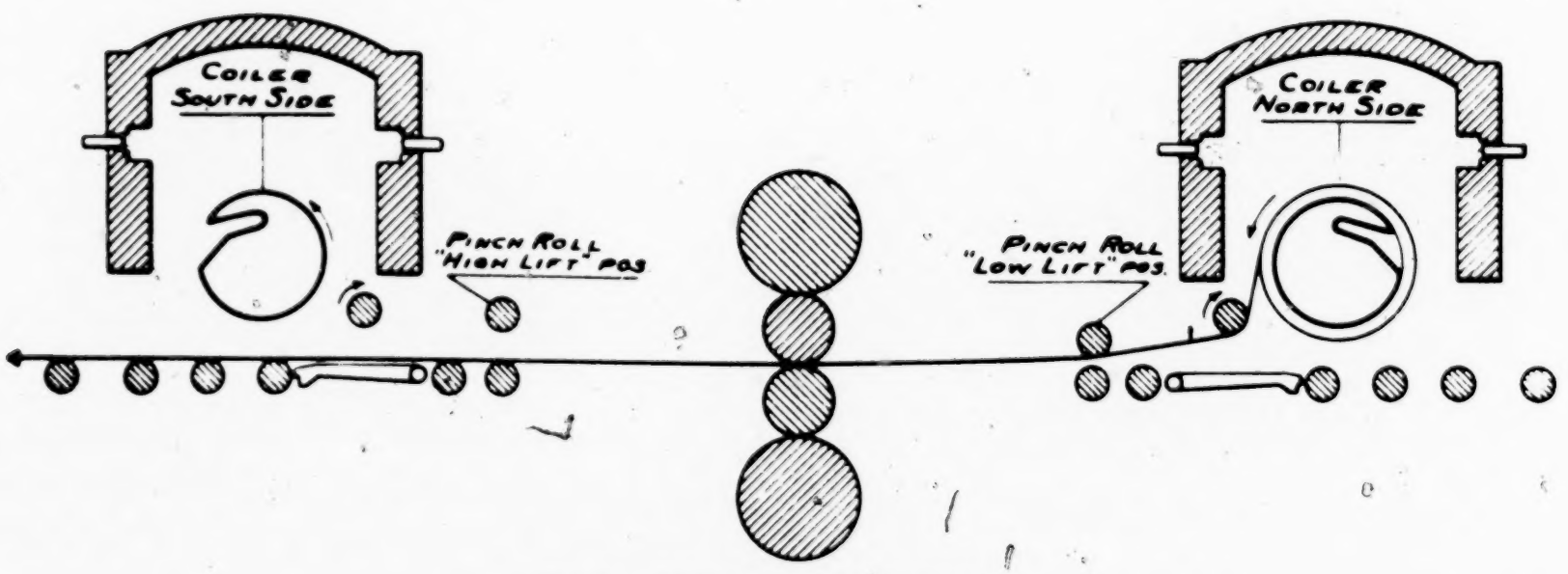
OPERATIONAL DRAWING NO: 6

NORTH →

ORIGINAL INSTALLATION



FINAL PASS STARTED



FINAL PASS DURING ROLLING

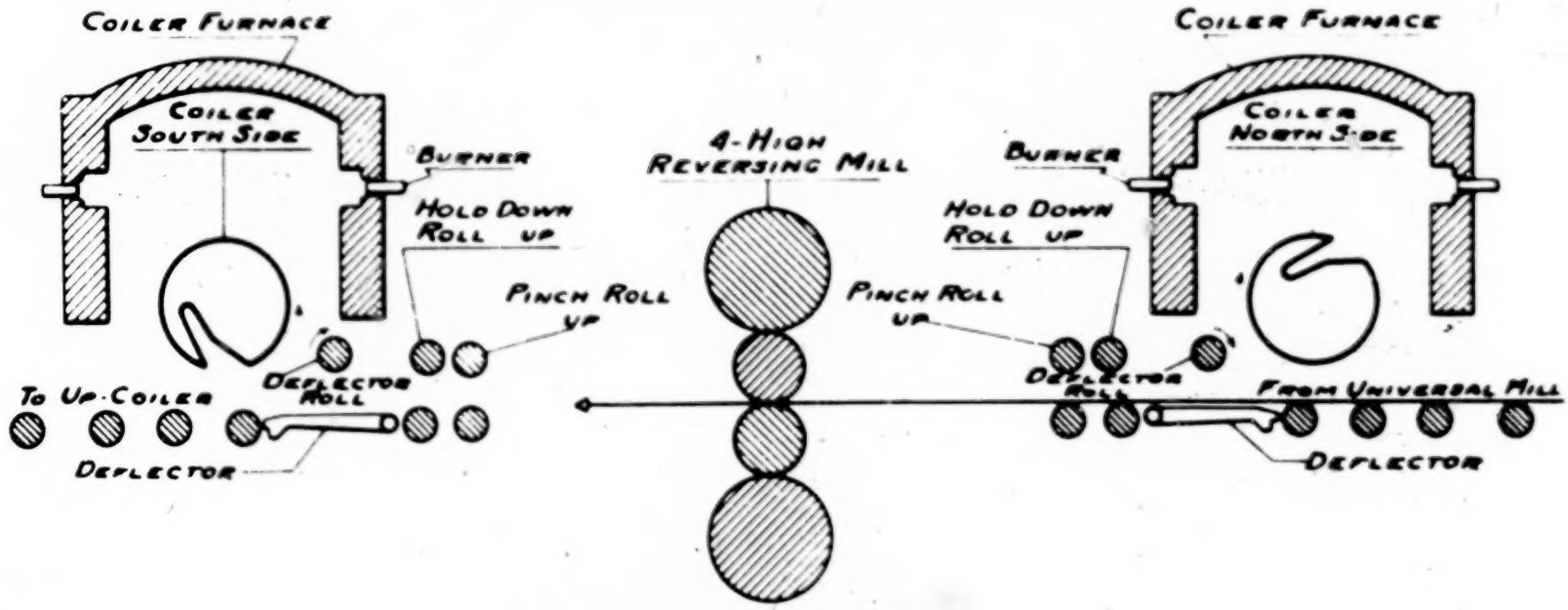
A17

CRUCIBLE HOT STRIP MILL

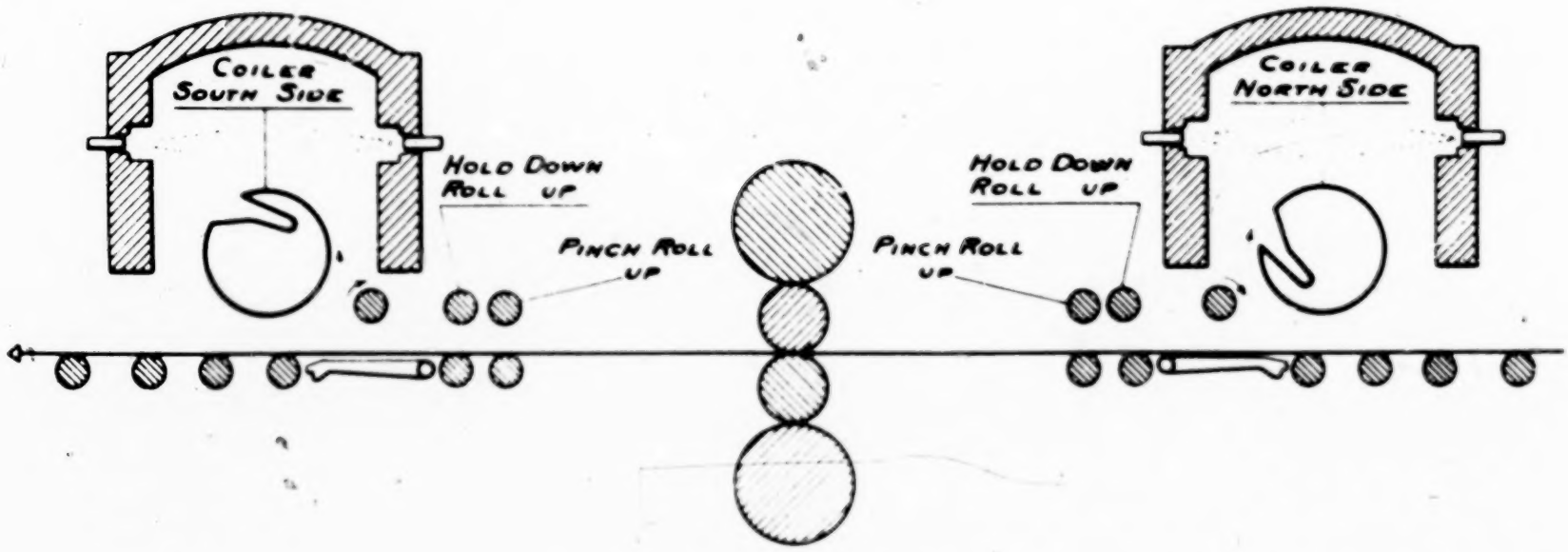
OPERATIONAL DRAWING NO. 7

NORTH →

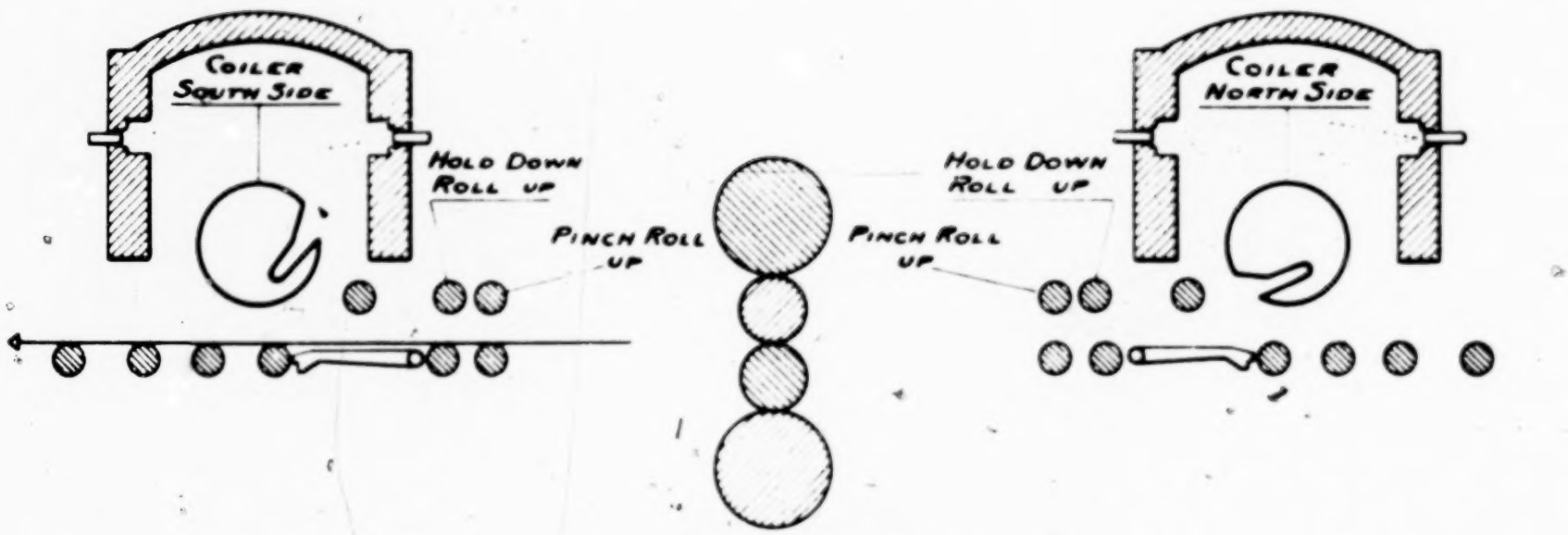
MODIFIED INSTALLATION



FIRST PASS STARTED



FIRST PASS ROLLING



FIRST PASS COMPLETED

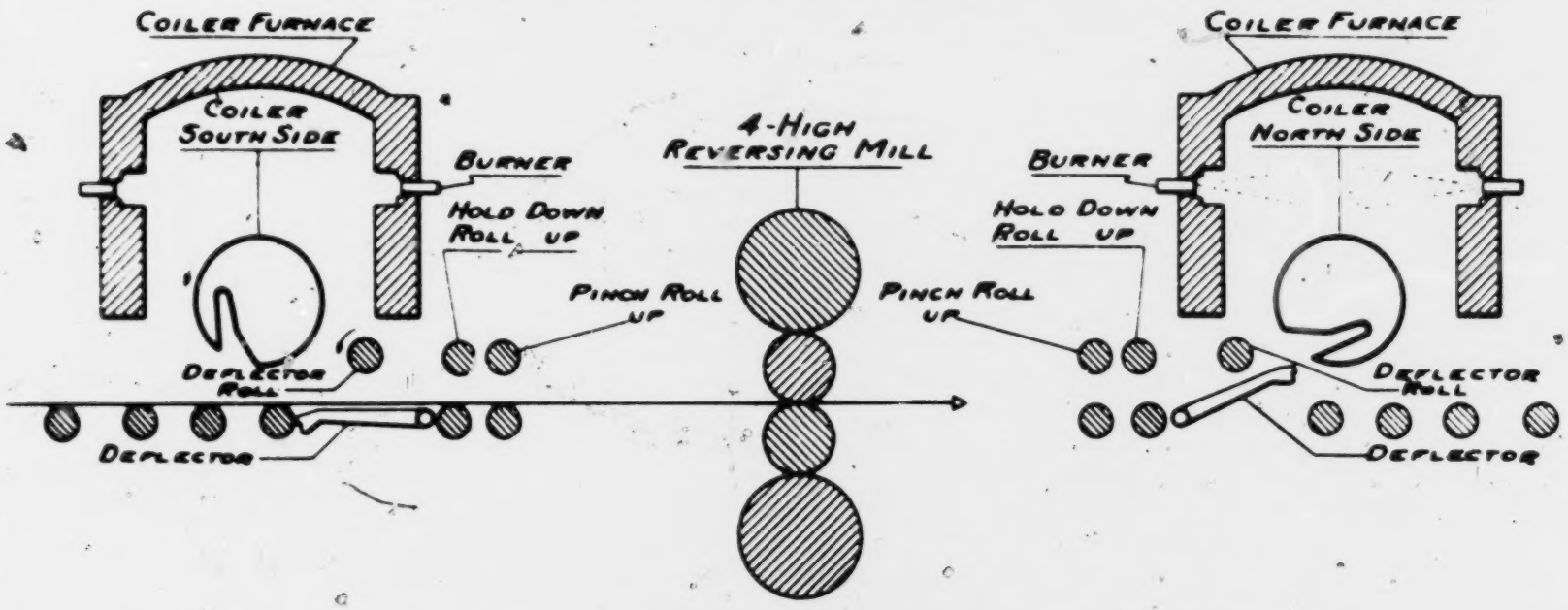
A18

CRUCIBLE HOT STRIP MILL

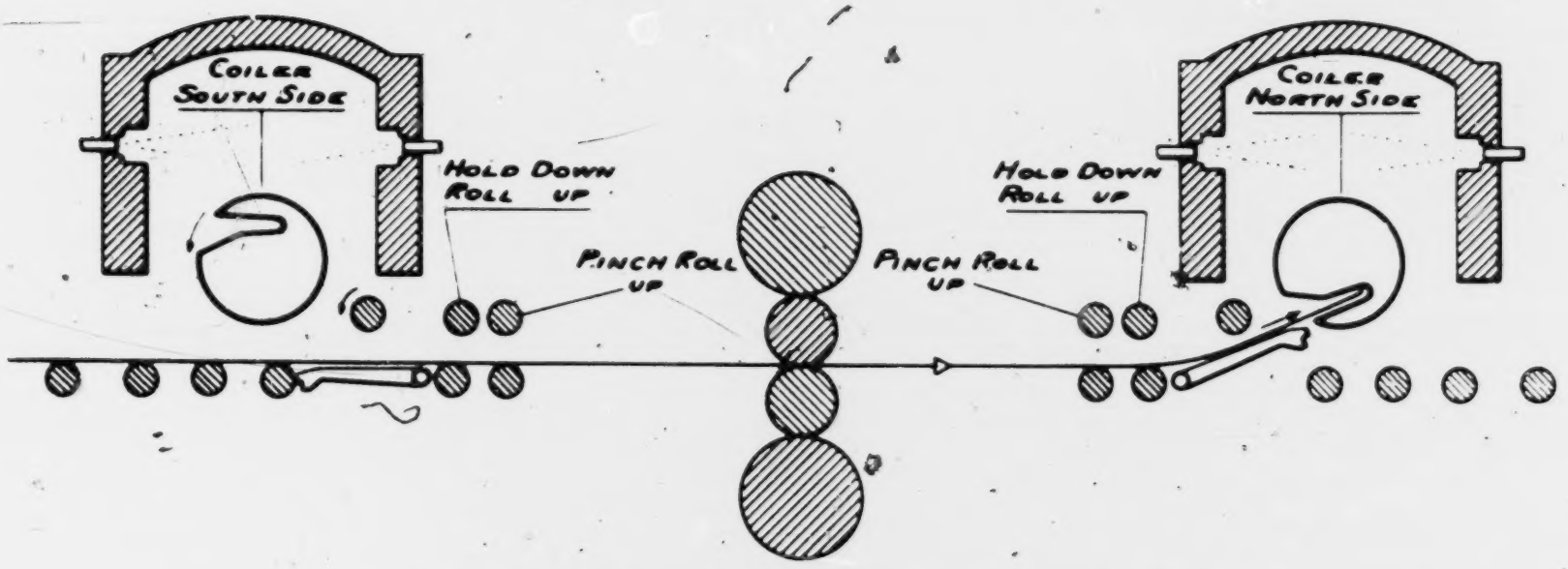
OPERATIONAL DRAWING, NO. 8

NORTH →

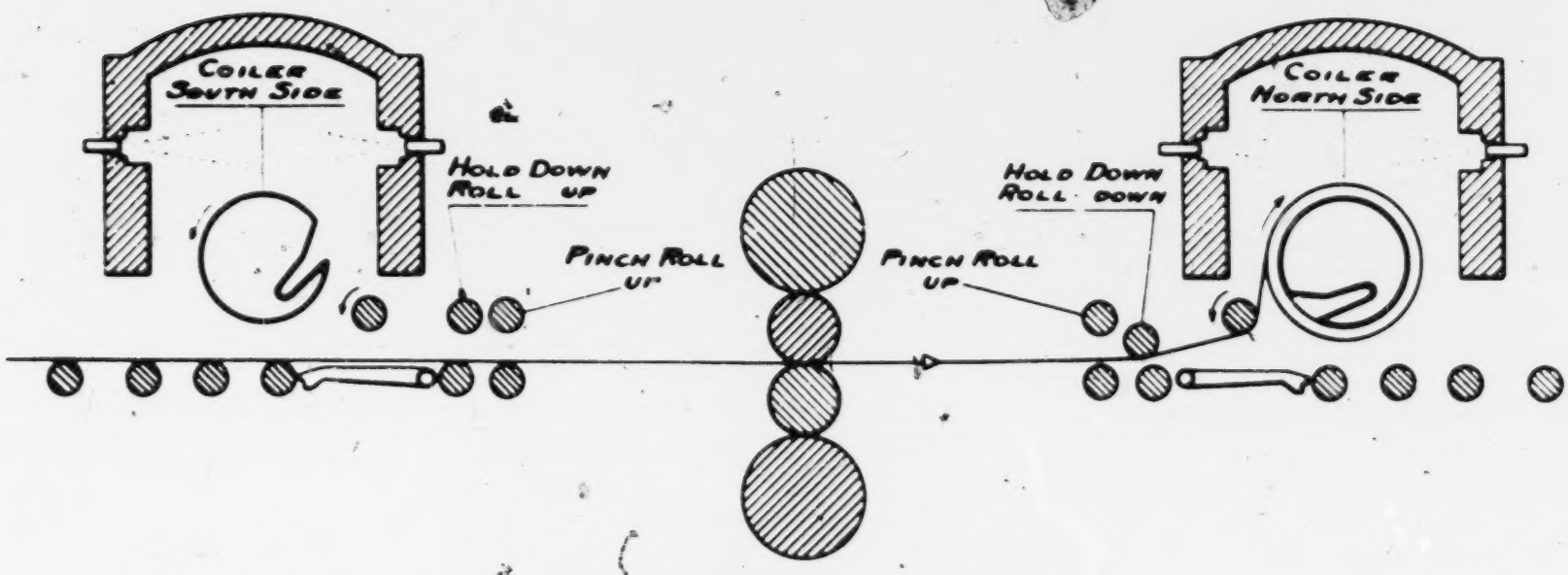
MODIFIED INSTALLATION



SECOND PASS STARTED



SECOND PASS - STRIP ENTERING COILER ON NORTH SIDE



SECOND PASS DURING ROLLING

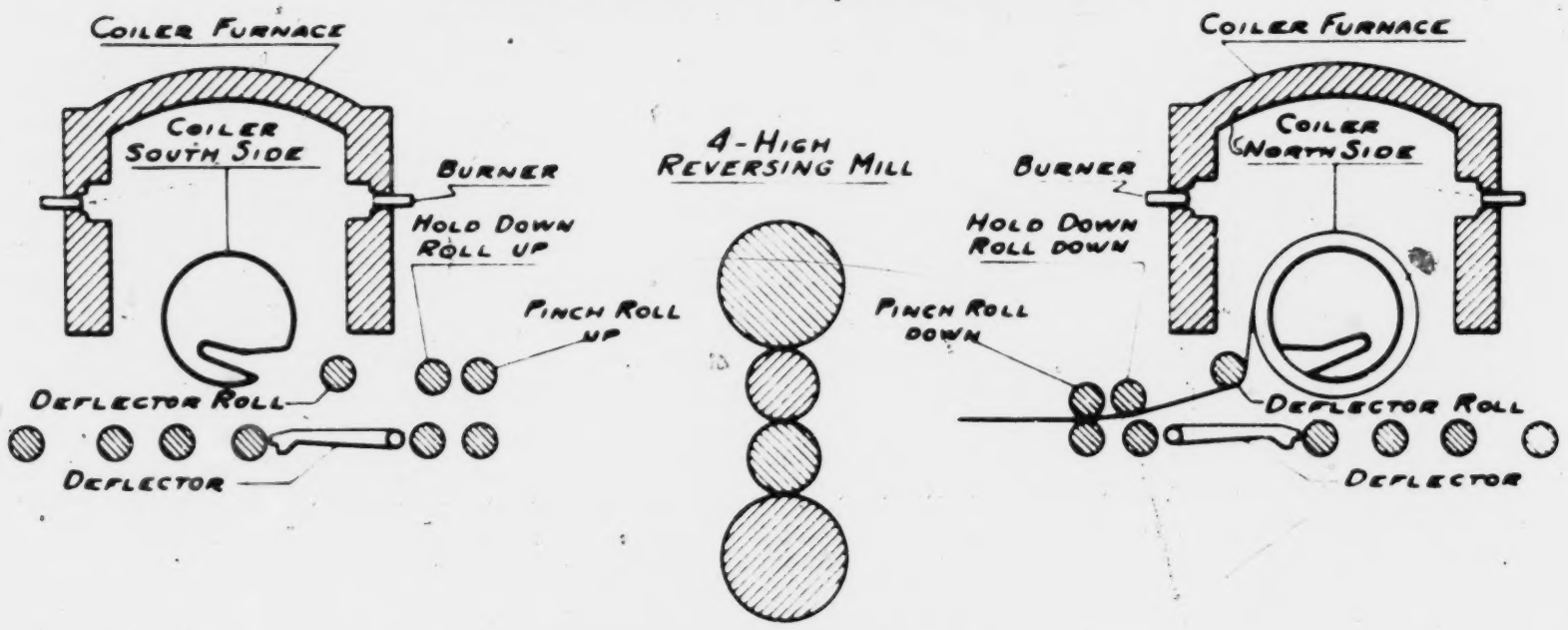
A19

CRUCIBLE HOT STRIP MILL

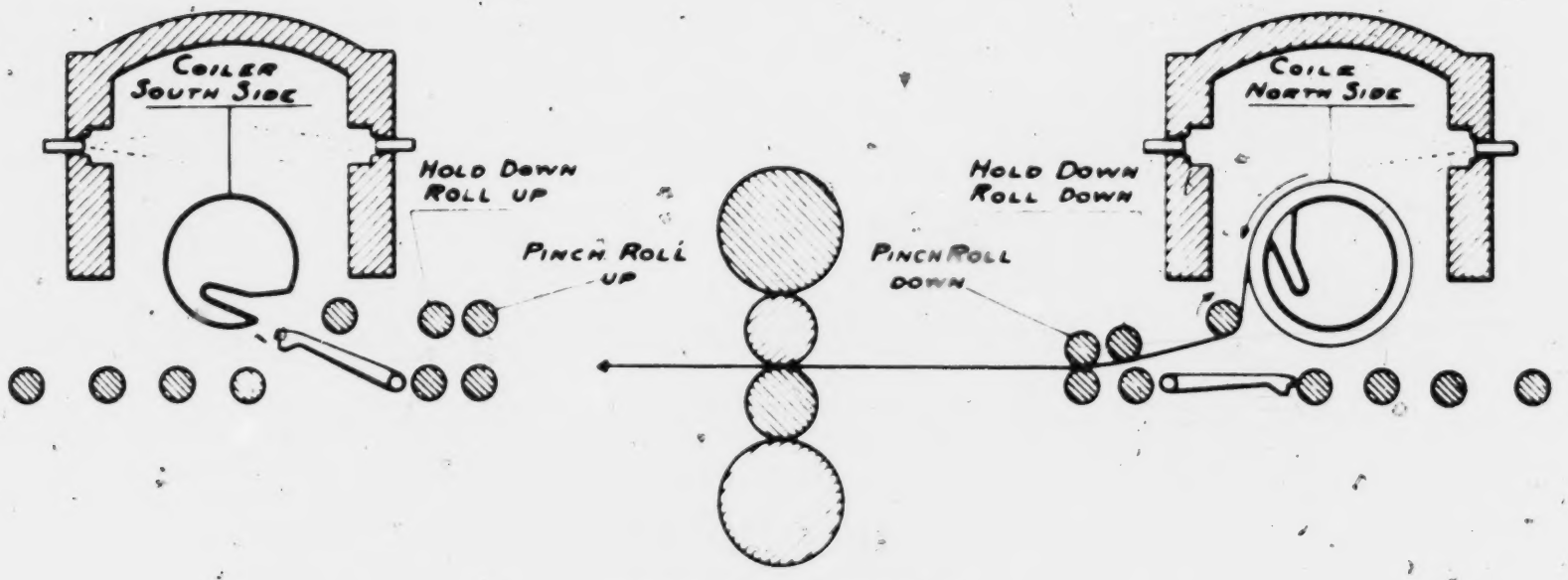
OPERATIONAL DRAWING NO. 9

NORTH →

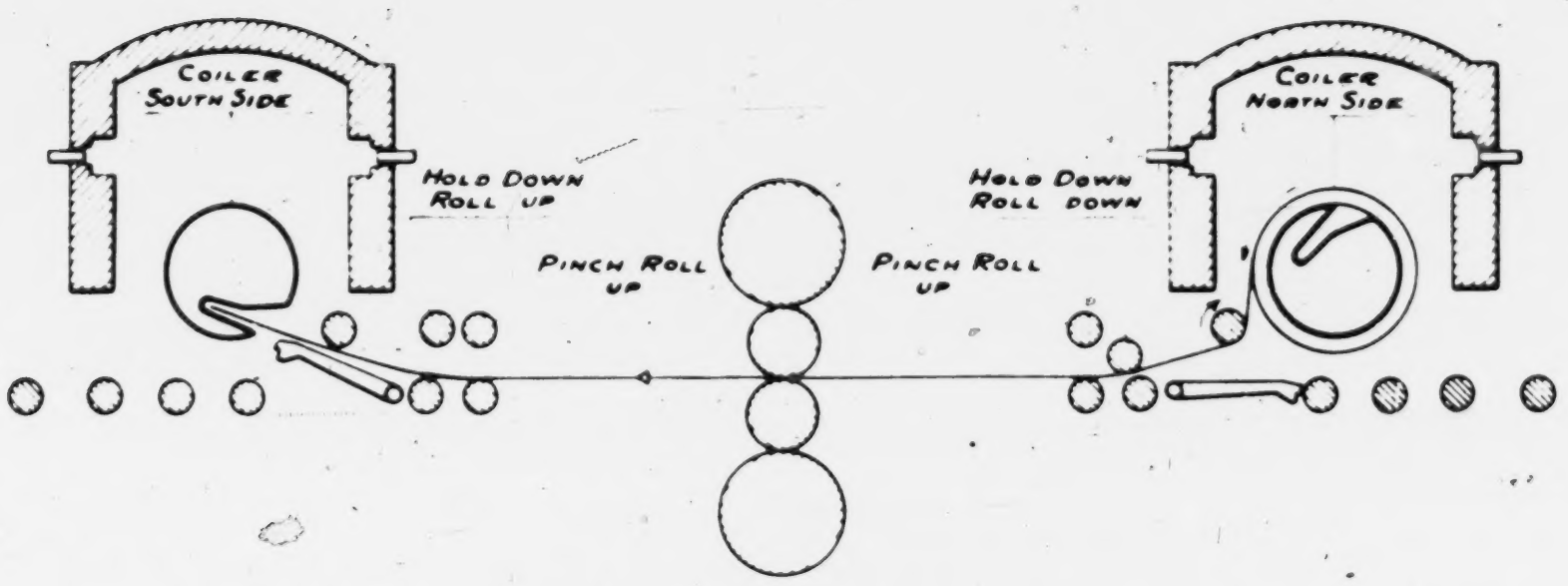
MODIFIED INSTALLATION



SECOND PASS COMPLETED



THIRD PASS STARTED



THIRD PASS ENTERING SOUTH COILER

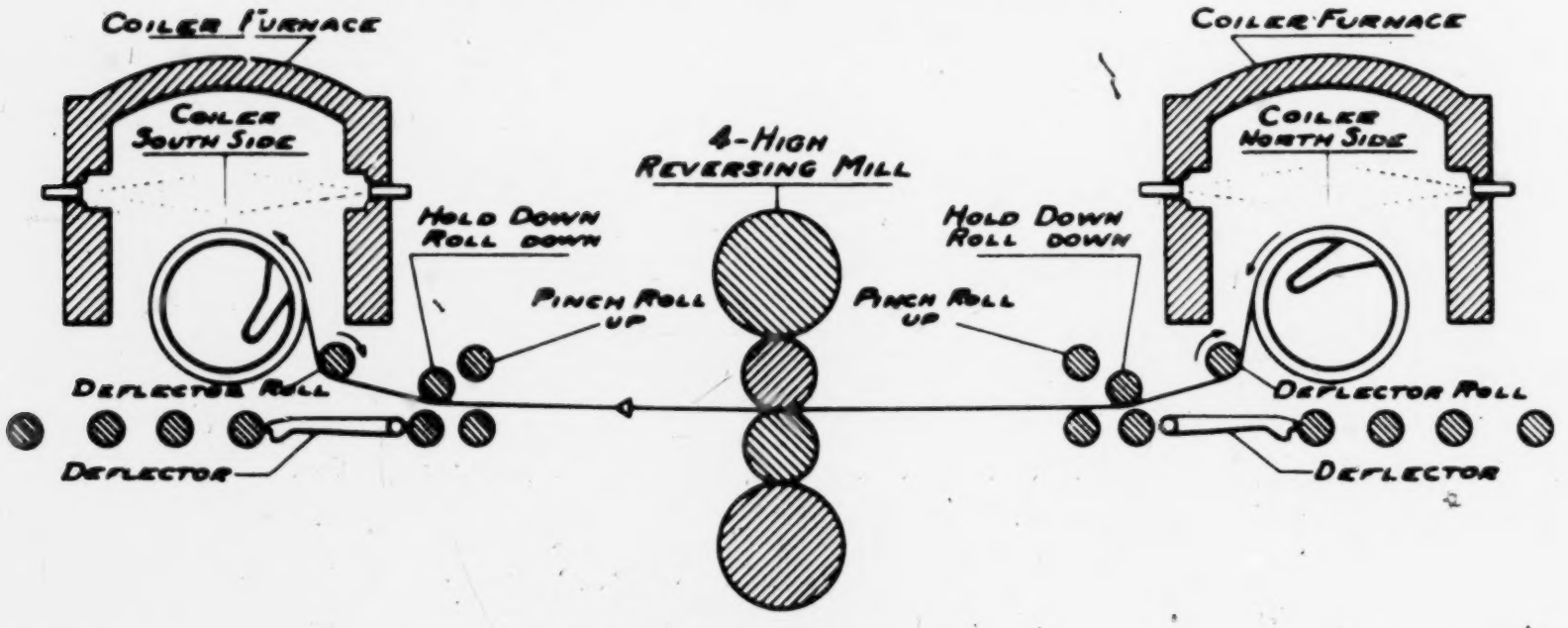
A 20

CRUCIBLE HOT STRIP MILL

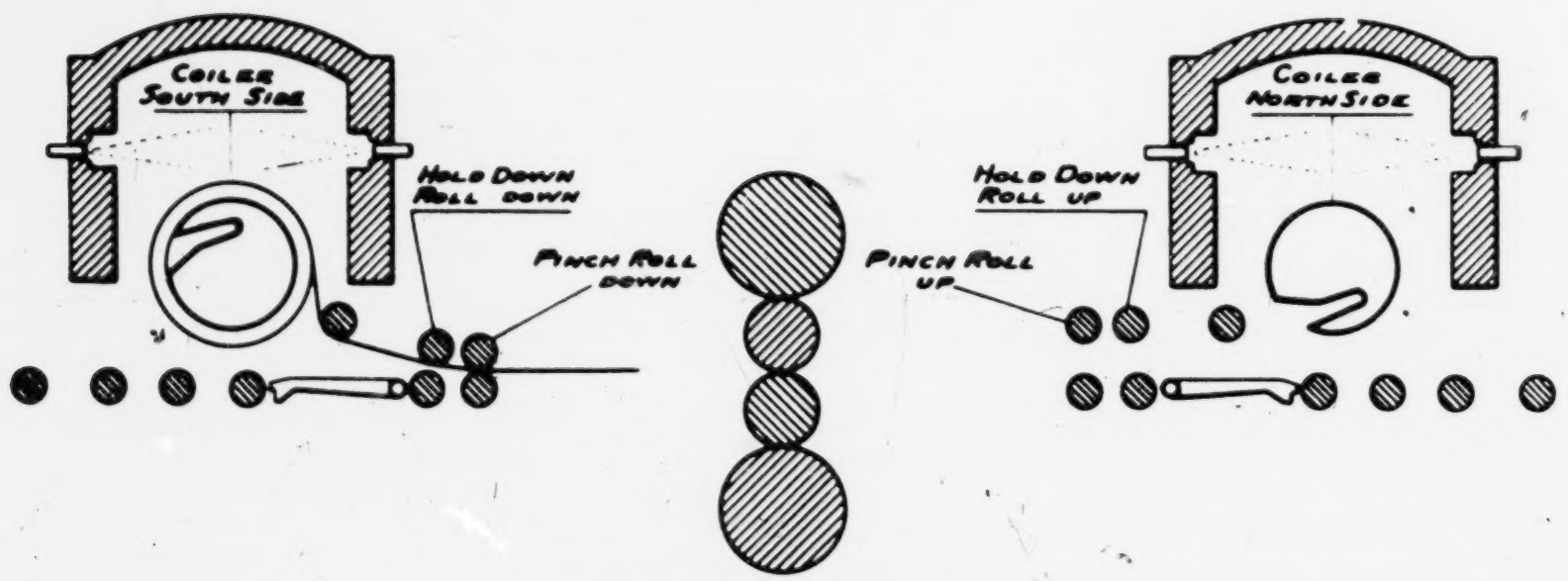
OPERATIONAL DRAWING NO. 10

NORTH →

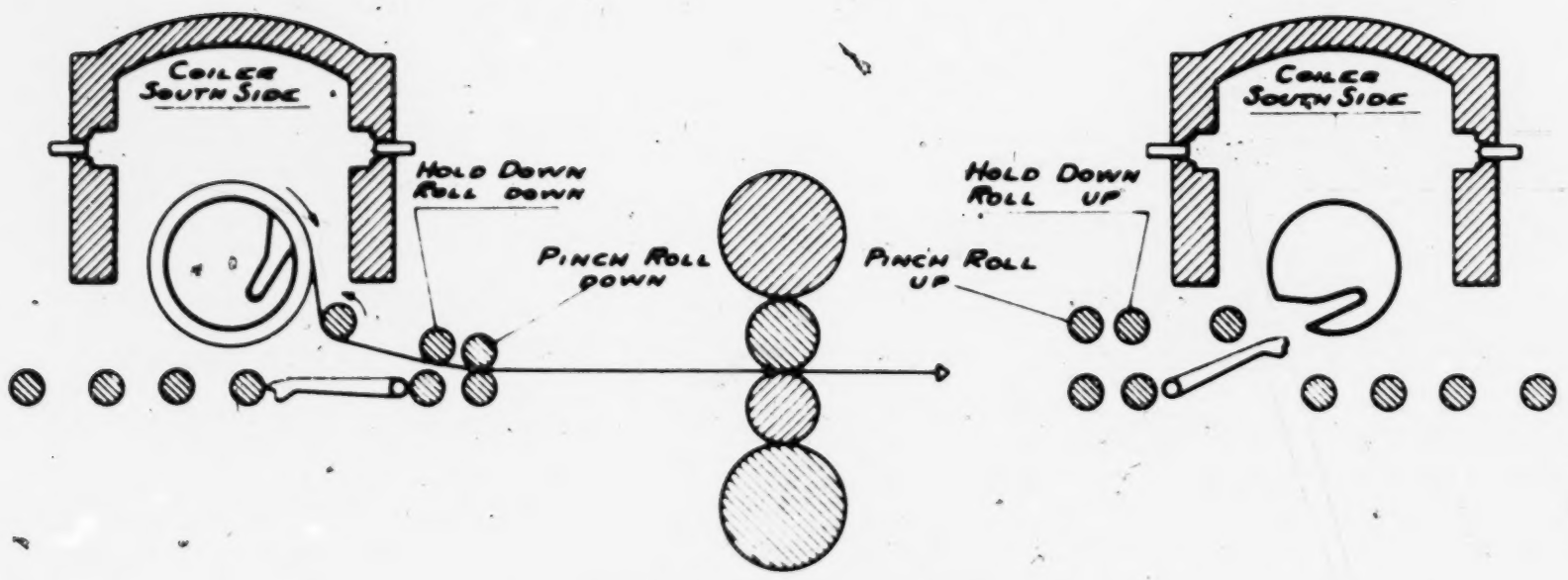
MODIFIED INSTALLATION



THIRD PASS ROLLING



THIRD PASS COMPLETED



FOURTH PASS STARTED

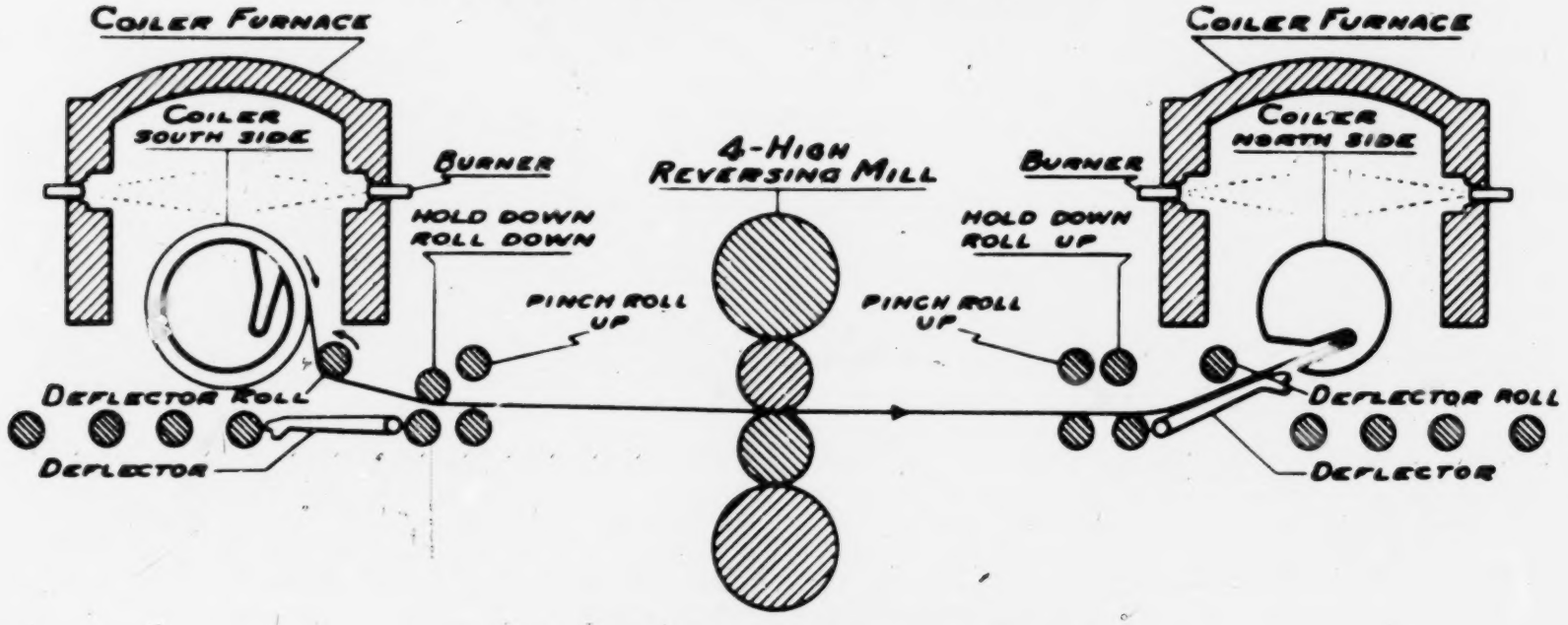
A 21

CRUCIBLE HOT STRIP MILL

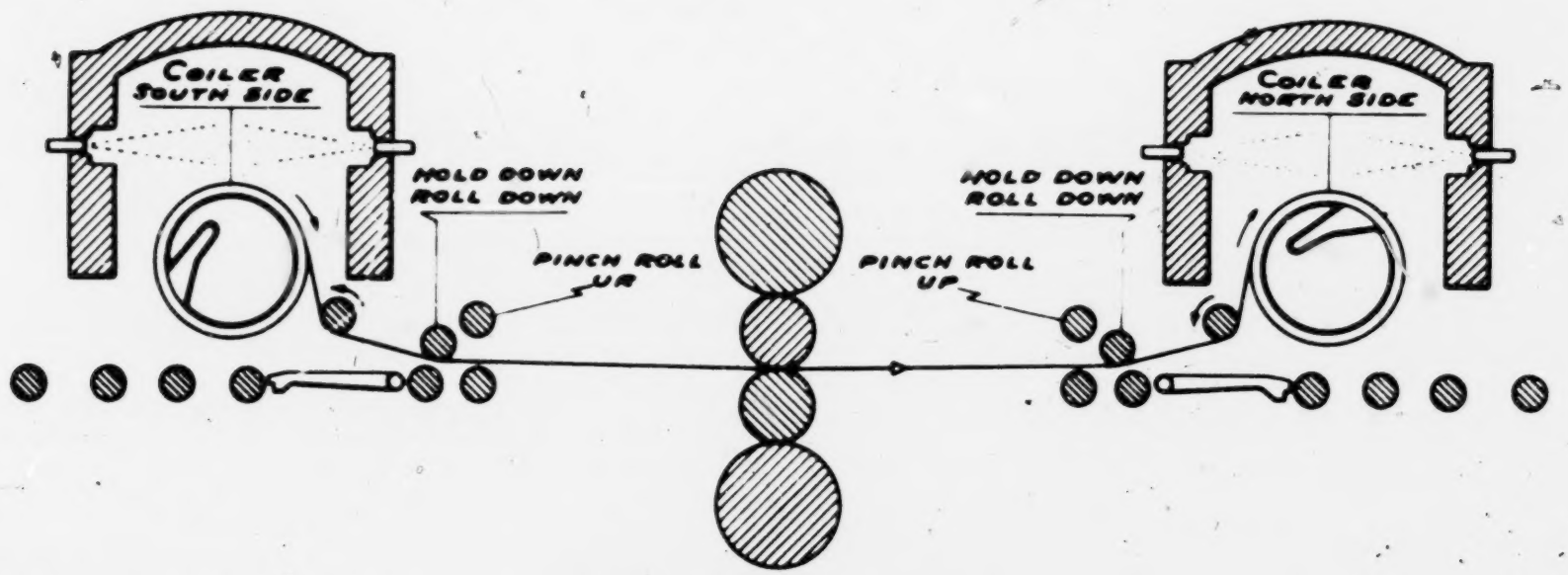
OPERATIONAL DRAWING NO. 11

NORTH →

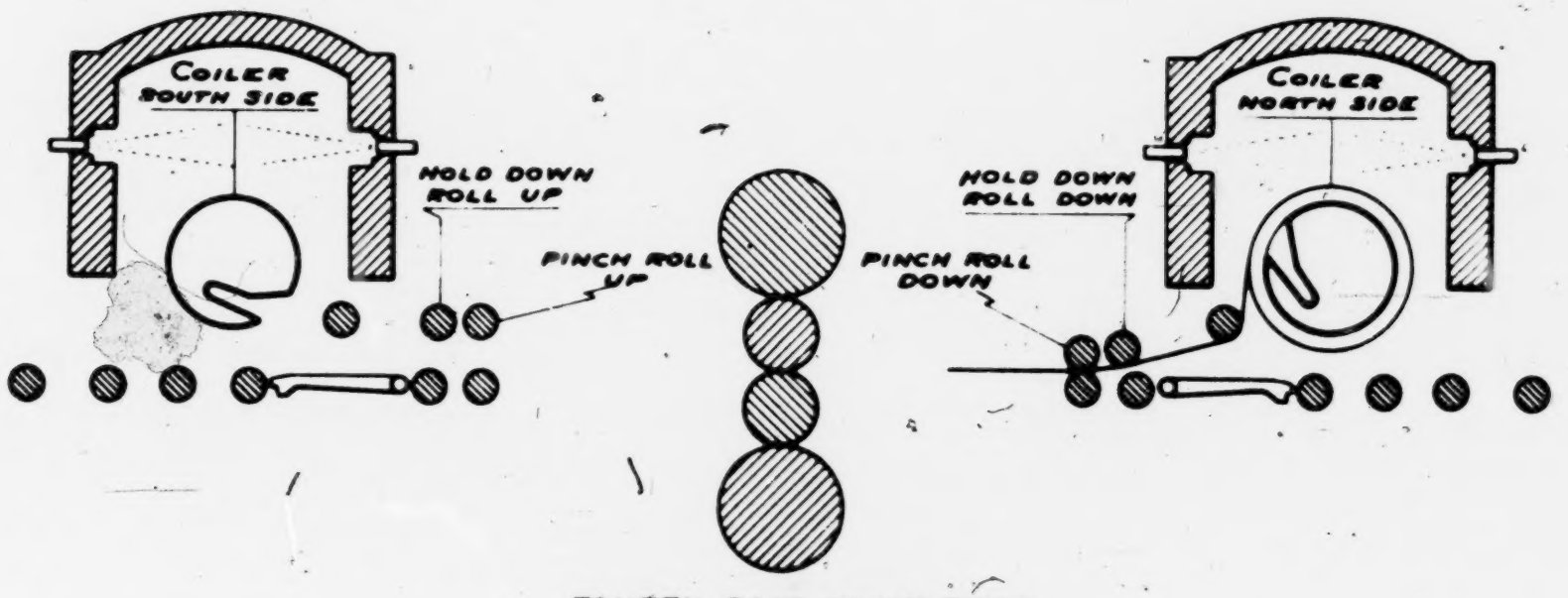
MODIFIED INSTALLATION



FOURTH PASS ENTERING NORTH COILER



FOURTH PASS ROLLING



FOURTH PASS COMPLETED

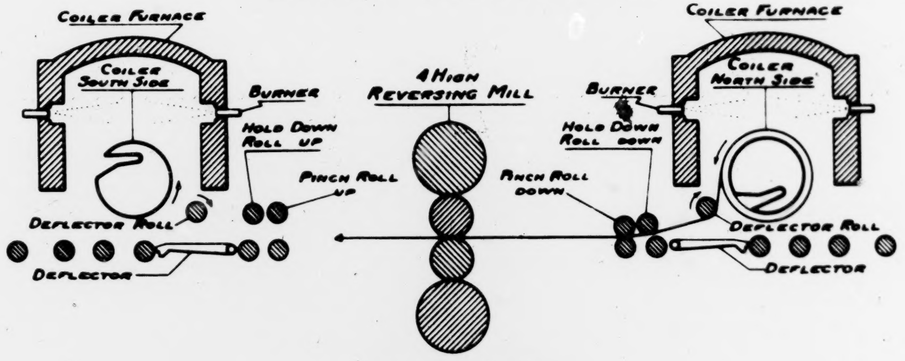
A 22

CRUCIBLE HOT STRIP MILL

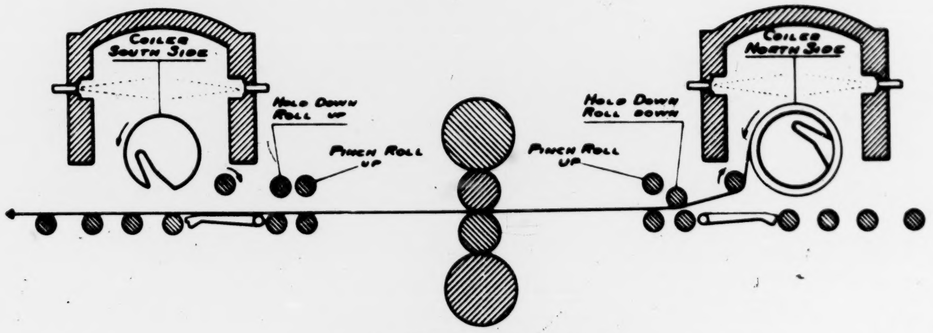
OPERATIONAL DRAWING NO. 12

NORTH →

MODIFIED INSTALLATION



FINAL PASS STARTED

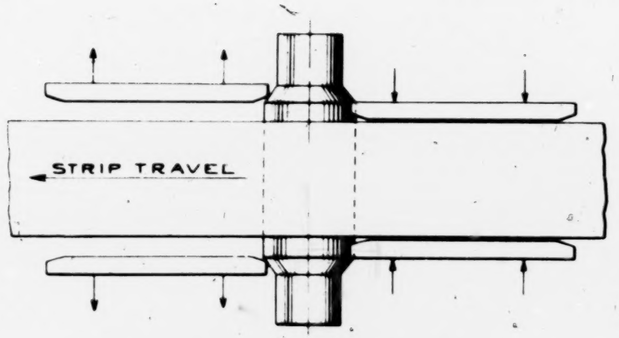


FINAL PASS DURING ROLLING

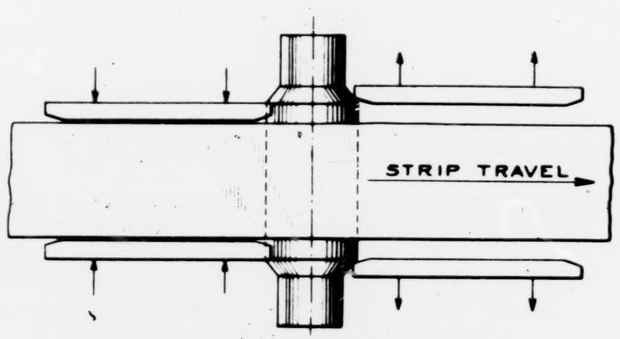
A 23

CRUCIBLE HOT STRIP MILL

SIDE GUIDE POSITIONS DIAGRAMATICALLY ILLUSTRATED



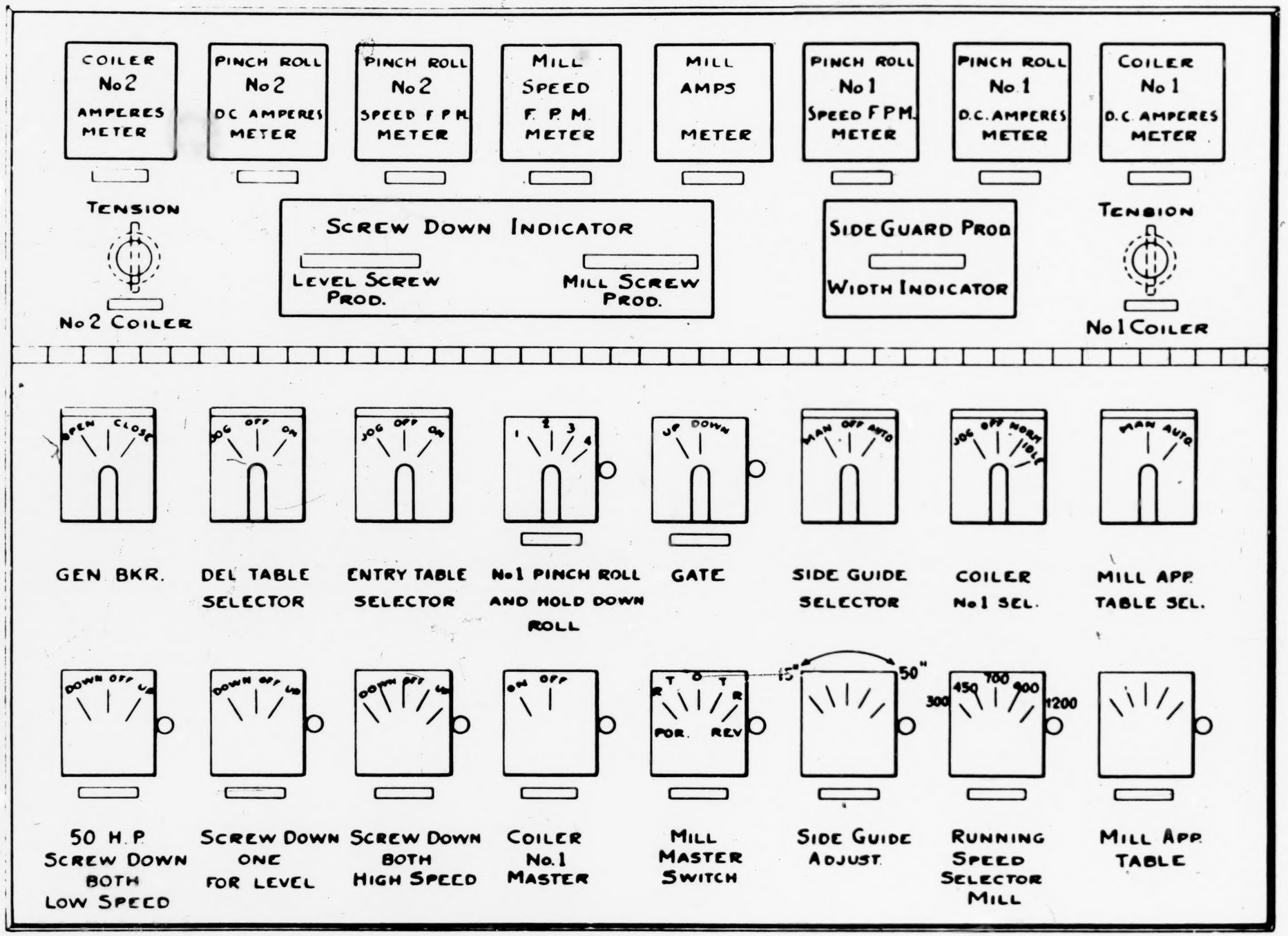
THREADING & RUNNING POSITIONS
TRAVEL TO LEFT



THREADING & RUNNING POSITIONS
TRAVEL TO RIGHT

CRUCIBLE HOT STRIP MILL

4HI REVERSING MILL OPERATOR'S DESK PANEL



CRUCIBLE HOT STRIP MILL

4 HI REVERSING MILL, ASSISTANT OPERATOR'S DESK PANEL

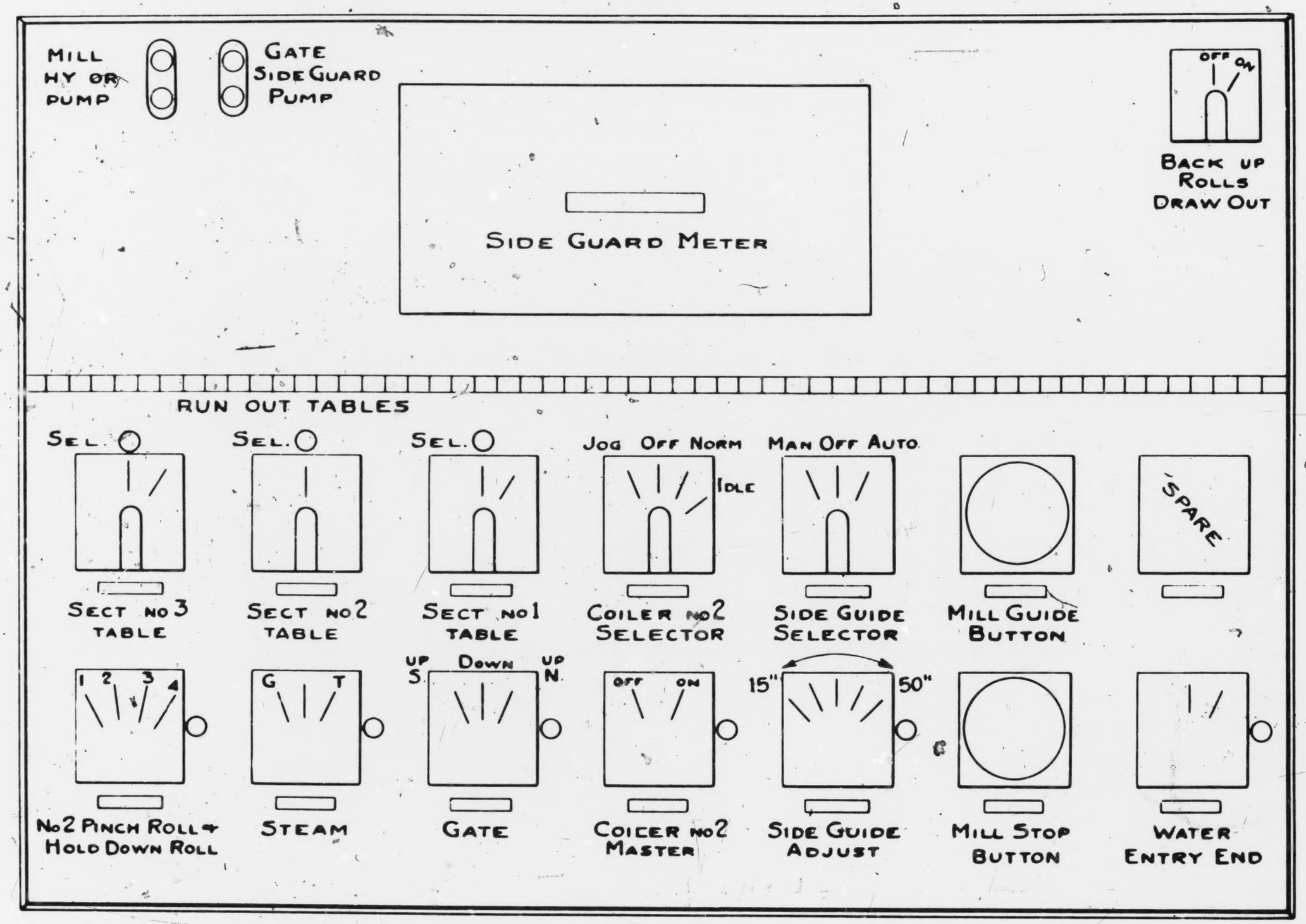


EXHIBIT D-7

5-Panel Fold-out Chart re Montgomery Patent 065

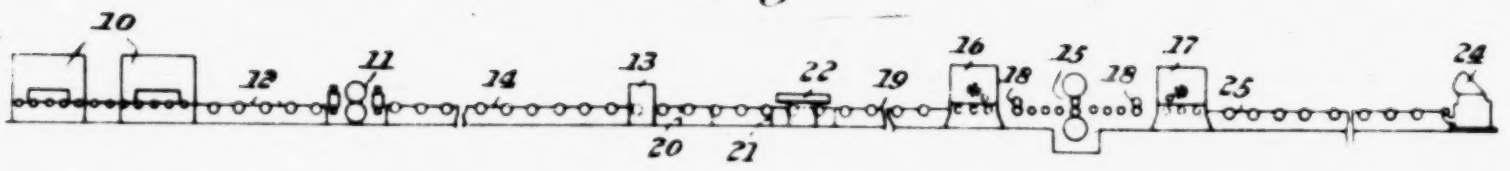
EXHIBIT D-7

July 13, 1937. **A. B. MONTGOMERY** **2,087,065**

METHOD AND APPARATUS FOR ROLLING

Filed Jan. 19, 1934

Fig. 2.



In the U. S. patent granted July 18, 1933 to Keeney, et al., No. 1,918,968, there is disclosed a four-high reversing mill with heating furnaces on opposite sides thereof for hot rolling strip. My invention is concerned chiefly with improvements upon the method and apparatus disclosed in said patent.

For certain classes of product, it is desirable to provide a finish on the hot strip superior to that which can be obtained with the mill shown in the Keeney patent, in which the entire reduction from the slab to the strip is effected by the same rolls.

*** * * * ***

In accordance with my invention, I take a slab after it has been properly heated in a suitable furnace and subject it to repeated passes through a universal mill to elongate it considerably without materially increasing its width. The ends of the piece are then sheared off to remove the ears projecting therefrom. The material is then passed into another reversing mill, e. g., that of the Keeney patent, with heating furnaces on opposite sides thereof, where it is subjected to further rolling with coiling between passes. After the material has been reduced sufficiently in the four-high mill, it is wound on a final coiler.

*** * * * ***

The operation of the apparatus above enumerated to perform the method of my invention may be described briefly as follows: The slabs are fed into the furnaces 10 to be heated prior to rolling in the mill 11. The slabs are initially 2" to 14" thick and of suitable width and length to provide the desired dimensions of finished hot strip. The heated slabs are passed back and forth through the universal mill 11, which effects a slabbing operation, until the slab is reduced to a thickness of ½" or less, with a corresponding elongation, and is cooled to a point where free scaling substantially ceases. The partially reduced slab is then forwarded to the four-high mill 15. The ends of the hot slab, however, are sheared off by the shear 13 before the piece arrives at the coiling mill.

AMENDMENT OF APRIL 27, 1937
(File Wrapper, pp. 41-42, 43)

(Submitting as claims 20-24 what became claims 1-4 of the patent)

REMARKS

This amendment is filed as a result of an interview accorded applicant's attorneys by the Principal Examiner and the Assistant Examiner on April 21st. At the interview, the above claims were discussed and it was agreed that they were allowable and that the filing of an amendment substituting them for the claims previously in the case would cause the application to be allowed. In order to complete the record, we include herebelow in brief form the argument which was presented to the Examiners orally at the interview.

The rejection on the ground that the claims defined the same method as that taught by Steckel and Keeney and that the only difference between the latter and applicant's method is in the apparatus, overlooks the fact that applicant's method differs from that of the references from the standpoint of mere manipulation if no other.

A method, simply defined, is a series of operations performed on material to produce a useful change in its condition. The method disclosed by Steckel includes the flat-rolling of a slab in a four-high reversing mill, and then rolling the resulting break-down on the same mill, with coiling between passes. In contrast to this, applicant reduces the slab to a break-down by flat-rolling in one mill and completes the rolling in another mill with coiling between passes. The results produced by applicant's method are superior to what can be achieved with the patented method, and this is a further argument for an actual difference between the two. We submit that the difference in the manipulation of the material and an improvement in the product are sufficient to remove all doubt as to the existence of a novel method.

* * * * *

The present invention deals with an improvement of the Steckel method wherein the roughing of a slab into breakdown is done in the same heat as the finishing of the breakdown into a strip by rolling in the Steckel mill, but the rough rolling is performed in a preliminary or roughing mill. At first glance, this might seem to be a step backward in the art, viz., providing an additional mill to do work which heretofore was done in the same mill which performed the finish rolling. The time required for roughing is less than that necessary for the coiling passes. Applicant finds, nevertheless, that the provision of special roughing mill is advantageous, despite the cost thereof including, not only the mill but the driving motor and the control equipment. This means, however, that the finishing mill can operate at maximum efficiency at all times, being confined exclusively to high speed rolling with coiling between passes and not periodically converted from a high-speed strip metal [mill] to a slow speed-slabbing mill in accordance with the disclosure of the Steckel patent.

C. B. CUSHWA.

METHOD OF ROLLING SHEET METAL.

APPLICATION FILED AUG. 18, 1905.

904,605. Patented Nov. 24, 1908

FIG. 1

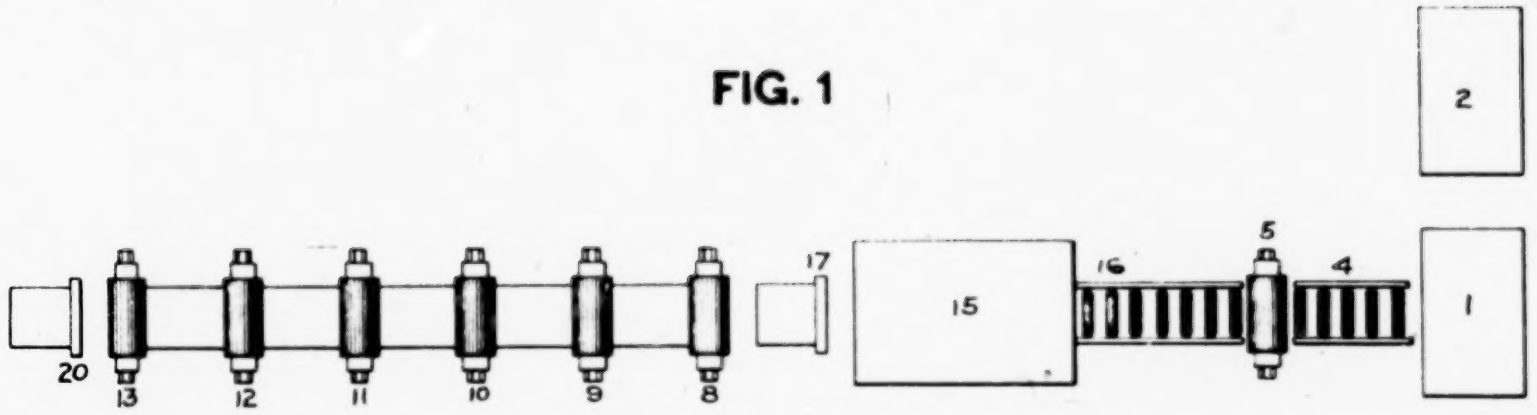


FIG. 2

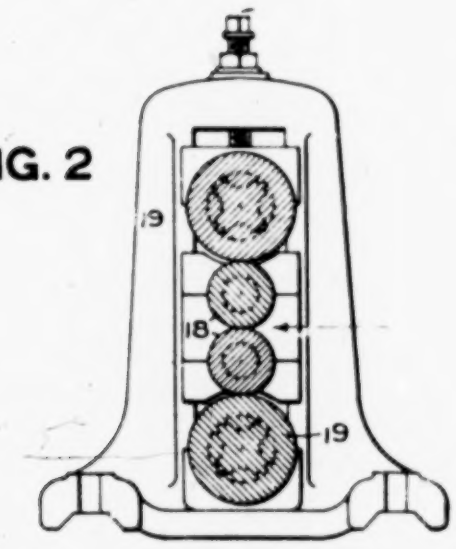
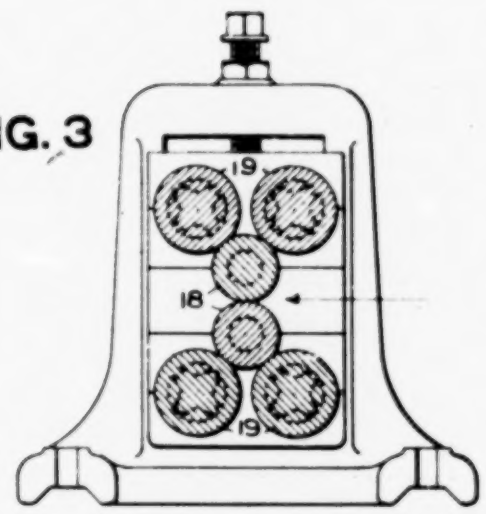


FIG. 3



My invention relates to a method of rolling metal in the form of thin sheets or strips, and its object is to provide a method whereby the many reheatings and the many manipulations and handlings of the metal employed in ordinary processes are dispensed with, thereby greatly reducing the cost of production; one wherein the amount of scrap produced is very largely reduced, and one wherein both faces of the sheet are subjected to the action of rolls, thus giving a bright and smooth surface on both sides.

* * * * *

It consists, generally stated, in starting with an ingot, billet or slab, roughing the same down to approximately ¼ inch or less in thickness, and then while still at the same heat passing the plates so produced singly through tandem mills consisting of a sufficient number of stands of small sized rolls to reduce the same to finished gage.

* * * * *

1, 2 and 3 represent suitable heating furnaces wherein the ingot, billet or slab is heated to a suitable rolling temperature. From these furnaces the heated ingot, billet or slab is transferred to the feed table 4 of the roughing down mill 5. The latter can be either a 2-high reversing mill or a 3-high mill. The heated ingot, billet or slab is passed back and forth through the mill 5 in well understood manner until it is reduced to a plate of approximately the width of the sheet to be formed and from about one quarter to a half inch thick.

* * * * *

The ingot, billet or slab is much cheaper to produce than the sheet bars heretofore necessary. Furthermore, it can be roughed to the gage specified at a single heat, and its gage is still such that the plate holds sufficient heat to enable it to be reduced to finished gage in the tandem or continuous mills represented by the rolls 8, 9, 10, 11, 12 and 13. To guard against delays on these finishing rolls I prefer to run the plate as it emerges from the mill 5 into a furnace 15, suitable live rolls 16 being employed to convey the plate through said furnace. In this furnace the plate, if delayed, is maintained at a good rolling heat, even though it be delayed a considerable time before entering the finishing mill. A shear 17 is provided for clipping off the front ragged end of the plate before entering the finishing mill. The finishing mill is shown as composed of six stands of rolls arranged in tandem, but the number thereof may be greater or less than this number, and in any event will be sufficient to reduce the plate to the finished gage.

* * * * *

The tandem mills are of the form shown in Figs. 2 and 3 in which the reducing rolls 18 are of comparatively small diameter. In order to give these small sized rolls sufficient stiffness each is backed by one or two large rolls 19, Fig. 2 showing one such backing roll and Fig. 3 showing two. The small sized rolls 18 have only a small area of contact with the metal being reduced, hence they press more deeply into, and more rapidly reduce or stretch the metal, than do the large diameter rolls usually employed in sheet mills. The small area of contact between such rolls and the plate also has the effect of reducing the amount of heat absorbed from the plate so that the latter is maintained at a better rolling heat than if larger rolls were used. The plate, after being roughed down is still very close to the initial heat of the blank, that is, a good bright red heat, and the further reduction thereof in the tandem mill described is effected so rapidly and with such a small absorption of heat by the rolls, that the plate reaches practically the thinnest gages before the temperature falls below a dull red.

* * * * *

What I claim is:

1. The method of rolling sheet metal, which consists in heating a suitable blank, and without further heating reducing the same to 20 gage United States standard, or thinner, by subjecting the same to successive rolling actions applied to small areas equally on both sides of the plate, thereby effecting the reduction at a temperature not less than a good dull red.

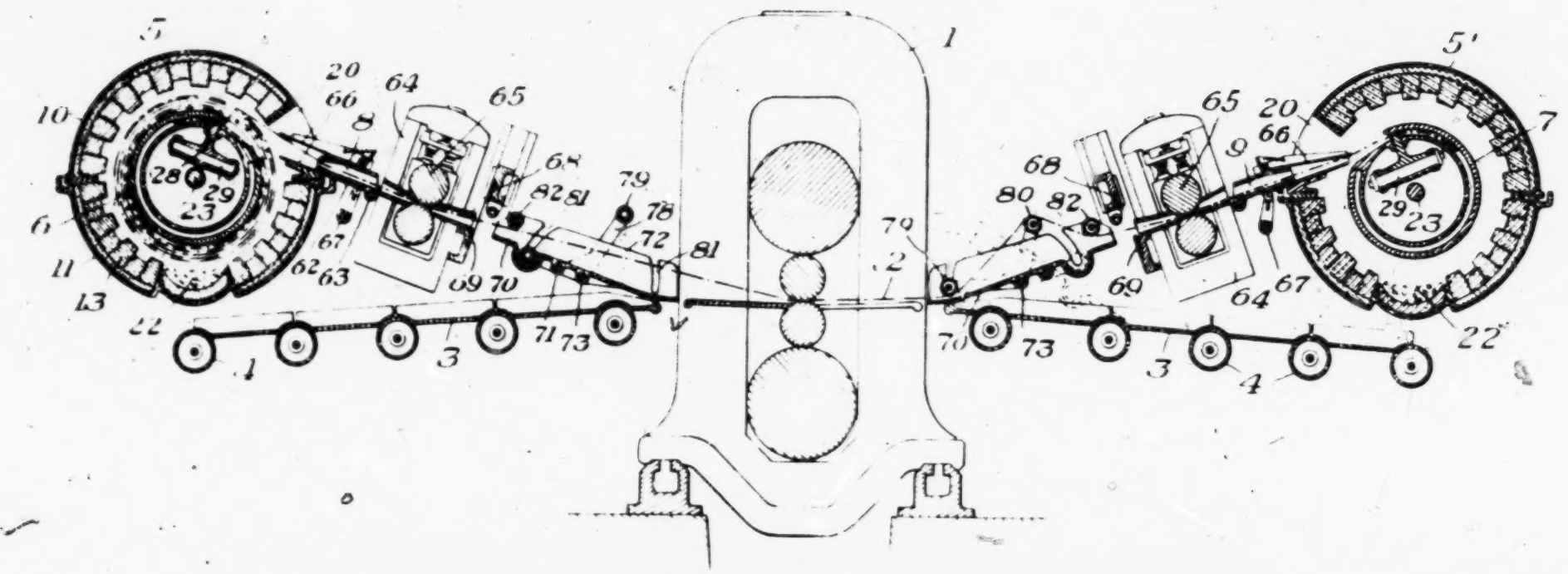
2. The method of rolling metal sheets, strips and the like, which consists in heating an ingot, billet, or slab, reducing the same by rolling and without further heating to a plate approximately ¼ to ½ inch thick, and then at the same heat reducing the same to finished gage by subjecting the same to successive rolling actions applied to small areas equally on both sides of the plate.

July 18, 1933. R M KEENEY ET AL 1,918,968

ROLLING MILL

Filed Jan. 12, 1928

FIG. 1



It is the primary object of the present invention to provide means whereby long and thin strips can be heated effectively and economically during the process of rolling, and therefore can be reduced to any thinness attainable by hot rolling, and the entire operation, after the initial roughing down, can, if desired, be carried out in a single stand of rolls.

* * * * *

The usual feed-tables 3 having driven rollers 4 are shown on the opposite sides of the stand of rolls 1.

* * * * *

Below the shear and extending into proximity to the stand of rolls 1 each of the chutes 8 and 9 has a tilting section 70 centrally mounted upon a rock-shaft 71. This tilting section has a floor and preferably opposite side walls 72. The tilting sections are provided so that they may be swung to a horizontal position, on one side of the rolls 1 to admit the strip coming from the roughing rolls of the mill, and on the other side to deliver the finished strip. Or if desired both sections may be swung out of the way and the strip be given one or more passes through the rolls 1 before it enters the chutes and coilers. Also by tilting either section to the position shown in dotted lines at the right hand side of Figure 1, any crop ends cut off by the shears can be delivered upon the roller table 3 and disposed of without delaying the operation of the mill.

* * * * *

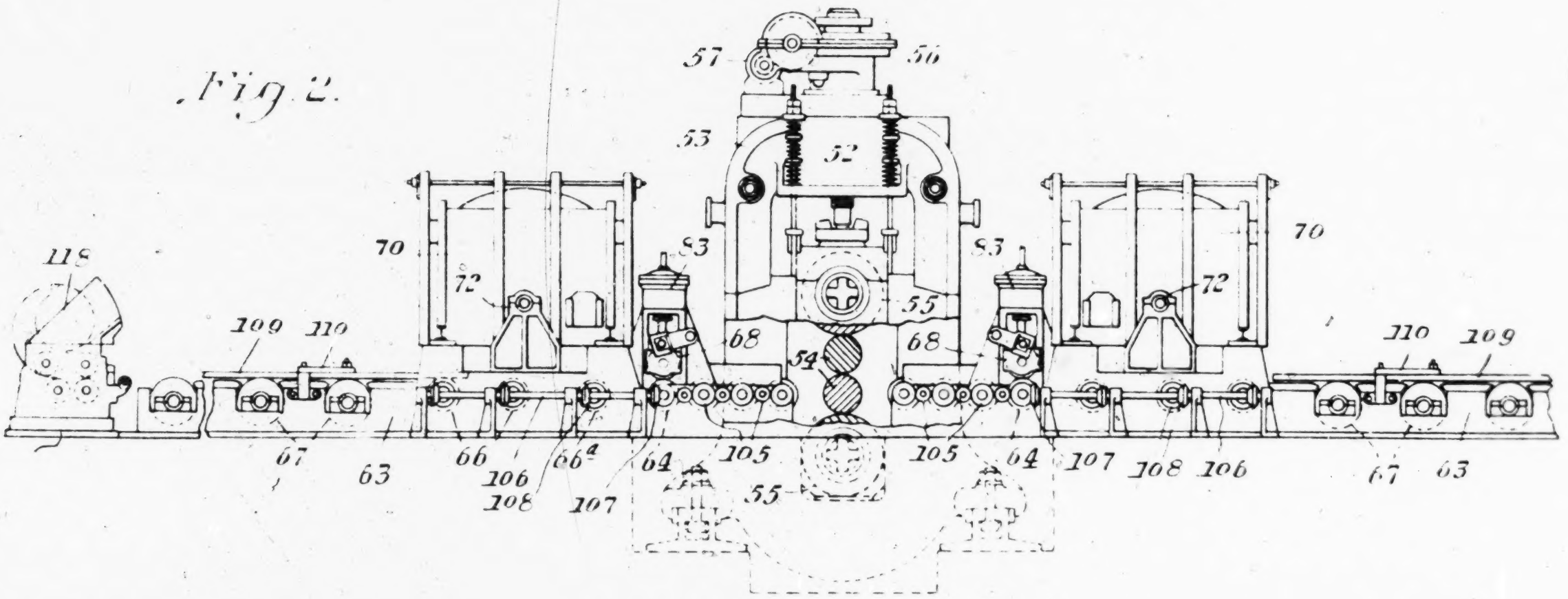
In operation, assuming that the table 3 at the right-hand side of Figure 1 leads from the roughing mill, the roughed-down strip will be carried on this table into and through the initial pass between the reducing rolls 1, which also act to feed the strip up the chute at the left and between the pinch-rolls, which are being driven at that time and which feed the strip on into the coiler, the guide 62, 66 being in advanced position to direct the leading end of the strip into the slot 25 in the reel. As soon as the leading end of the strip enters the slot 25 it is locked by the bar 28, and the coiler motor is started and the strip is wound on the reel, the pinch-roll motor being stopped and the driving shaft disconnected by opening of its magnetic clutch, so that during the winding operation the pinch-rolls act as idle guide rollers.

Oct. 16, 1934. A P STECKEL 1,977,214

METHOD AND APPARATUS FOR HOT ROLLING STRIP METAL

Filed May 4, 1931

Fig. 2.



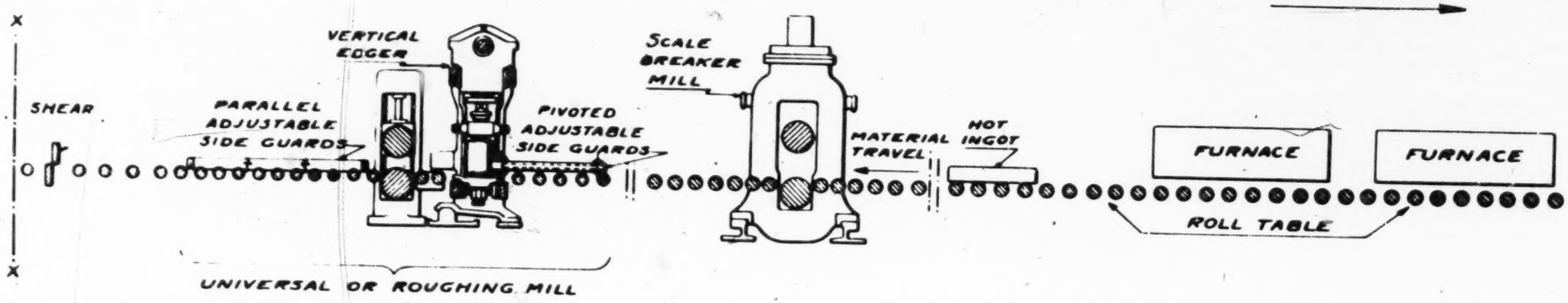
I provide a mill which is relatively simple and compact in construction, employing preferably but a single reducing stand, although it may in certain instances be desirable to divide the work between two stands.

* * * * *

I overcome these difficulties by initially hot rolling a piece of metal in the flat so as to reduce it in thickness sufficiently to permit of coiling it, and in the same heat feeding it from the coil and further reducing it. I preferably employ coilers on each side of the mill and after the initial flat rolling the material is coiled and uncoiled on each pass, the material being fed from a coil to the mill and being coiled up on the other side as it issues.

CRUCIBLE HOT STRIP MILL
DIAGRAMMATIC SECTION OF COMPLETE MILL

(D-7, J)



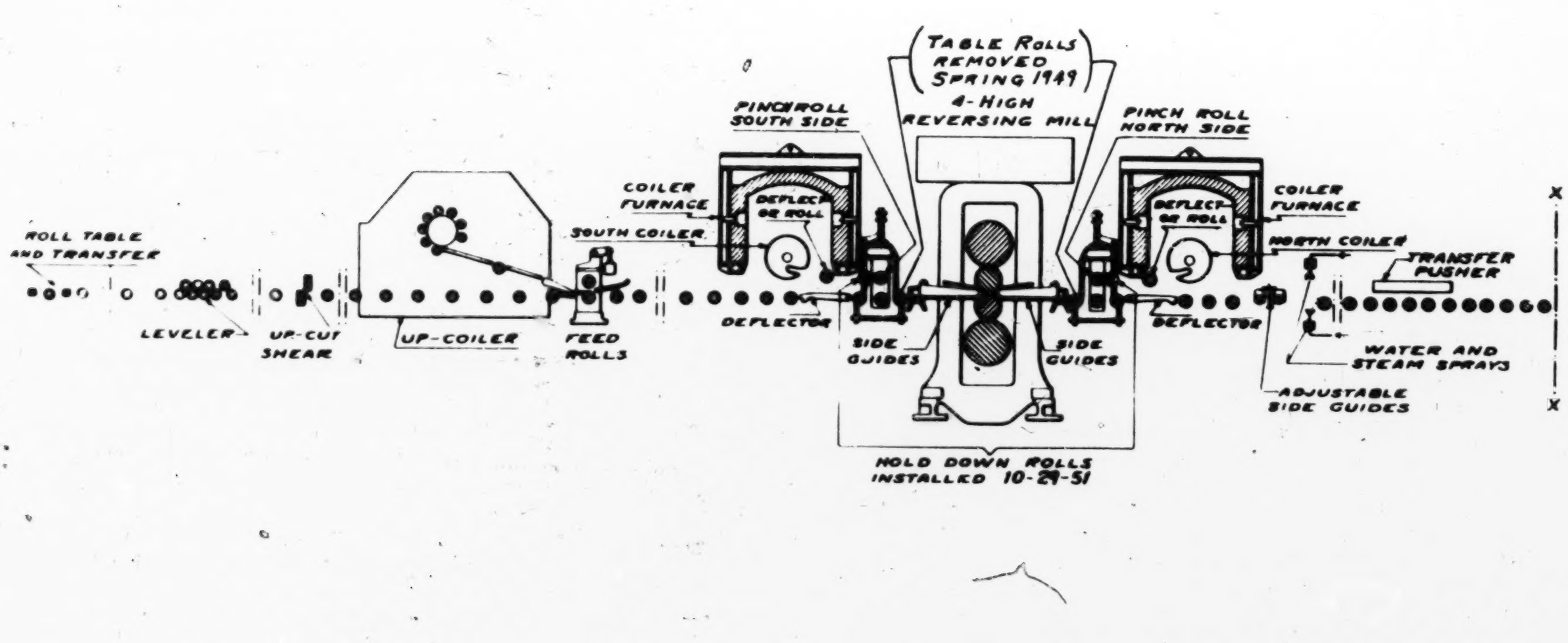


EXHIBIT D-8

ınel Fold-out Chart re Side Guide Control, Claim 10 of Montgomery 122

EXHIBIT D-8

March 2, 1937. A B MONTGOMERY 2,072,122

ROLLING MILL

Filed Dec. 4, 1934

Fig. 1.

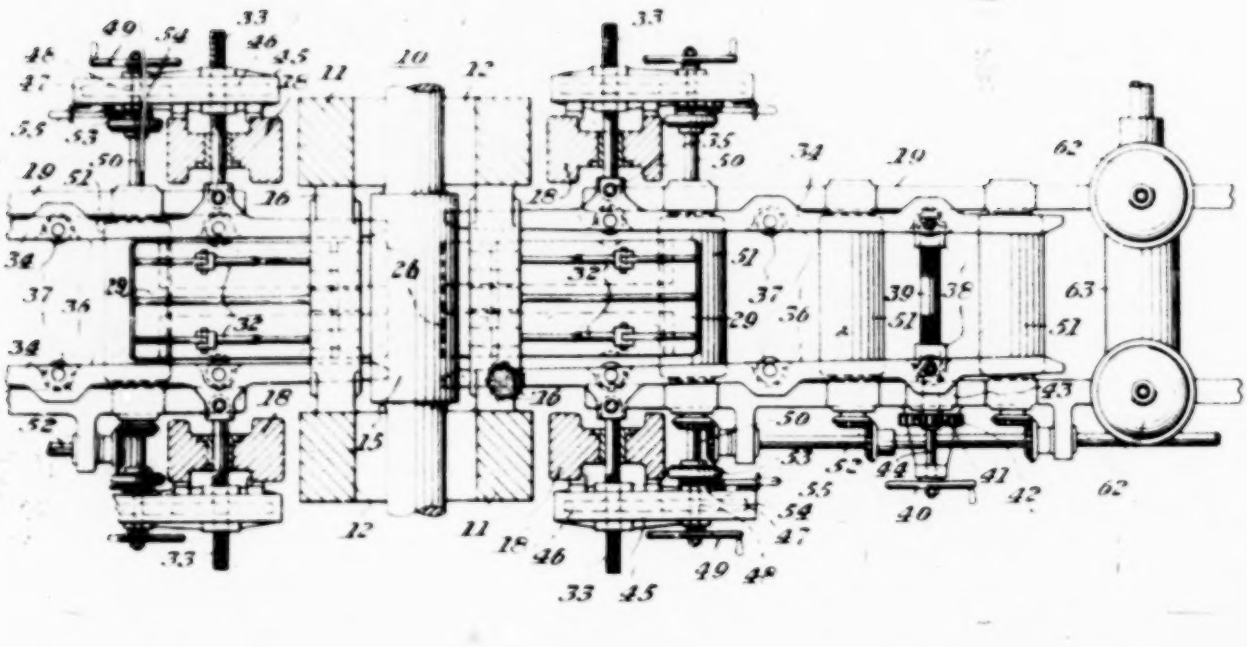
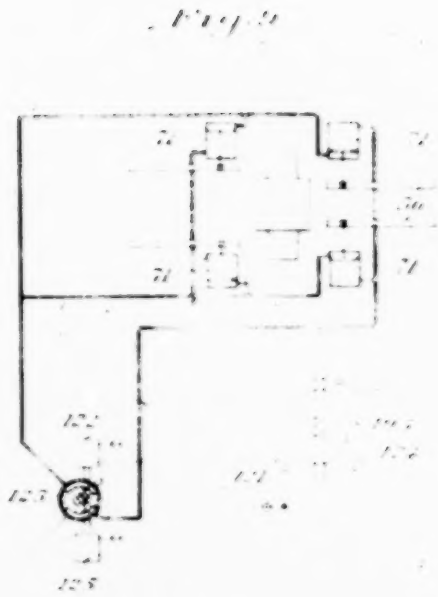


Fig. 9.



I have invented a rolling mill which overcomes the above mentioned disadvantages of the known mill construction. In accordance with my invention, I provide side guides on both sides of the mill and operate the guides successively to provide a parallel guiding throat on the entering side of the mill and a tapered guiding throat on the other side of the mill. The conditions of the guides on the two sides of the mills are reversed automatically by a change in the direction of the movement of the piece. Means are provided for adjusting the guides initially to cooperate with material of any desired width within the range of a particular construction.

* * * * *

Screw shafts 33 are slidably mounted in the housing 18 parallel to the axes of the mill rolls. Side guides 34 are supported on the screw shafts 33 by hinged joints 35. The guides 34 have a plane inner surface 36 with recesses into which anti-friction rolls 37 are let. The mill ends of the guides extend to a point closely adjacent the rolls, as shown in Figures 1 and 2. The outer ends of the guides are pivotally supported on nuts 38 traveling on a screw shaft 39 journaled in the side frames of the table 19. The ends of the screw shaft 39 are oppositely threaded so that on rotation of the shaft, the outer ends of the guides are moved toward or away from the center line of the table 19.

From what has been said, it will be apparent that my invention provides side guides which may be disposed in parallel relation, as shown on the left-hand side of the mill in Figure 1, or in angular relation, as shown on the right-hand side of the mill in Figure 1, for the purposes, respectively, of definitely and positively guiding the leading end of an advancing strip into the rolls at the proper angle thereto, and providing a tapering throat for receiving the end of the piece as it emerges from the mill. I shall now describe the mechanism for operating the guide supports to bring about the proper relation of the guides at the proper time.

The outer ends of the guides may be adjusted toward or away from each other through the shaft 39, as already described. This adjustment is effected by a hand wheel 40 having a pinion 41 meshing with a gear 42 along the screw shaft 39. A suitable pedestal bearing 43 is provided for the hand wheel shaft 44. The outer ends of the guides 34 are adjusted manually to the proper spacing before commencing the rolling.

The adjustment of the inner ends of the guides 34 is effected through the screw shafts 33. Gear cases 45 attached to the housings 18 enclose gear wheels 46 having their bores threaded for engagement with the shafts 33, and pinions 47 keyed to shafts 48. Hand wheels 49 permit manual adjustment of the screw shafts 33. These shafts are normally driven from extensions 50 of the shaft of one of the rolls 51 of the table 19. The rolls of the table are driven from a line shaft 52 through the usual bevel gears by a reversing motor, not shown. Between the shaft extensions 50 and the shafts 48 are positioned friction clutches 53 and jaw clutches 54 having operating levers 55. The purpose of the friction clutches is to permit the rotation of the shaft 48 to be arrested after a predetermined movement thereof without stopping the operation of the roll 51. The jaw clutches 54 permit the shafts 33 to be freed from the table drive while being manually adjusted.

The friction clutches 53 have detents 56 thereon cooperating with stops 57 on the housings 18 to limit rotation of the shaft 48 to the desired extent. After the detents engage the stops, the adjustment of the shafts 33 ceases but the roll 51 continues rotating with accompanying slippage of the clutches 53.

It will now be apparent that once the outer ends of the guides 34 have been adjusted, the inner ends of the guides will be spread to form a tapering throat or moved together to parallel position with the reversal of the drive for the rolls of table 19. The detents and stops controlling the amount of rotation of the friction clutches will determine the amount of movement imparted to the inner ends of the guides and may, if desired, be made adjustable. It will be understood, of course, that the guide-operating mechanism is designed so that the guides will be spread at the mill end when the table rolls are driven in such a direction as to move material away from the mill. At the same time, the guides on the opposite side of the mill will be actuated to parallel position. In this way, the material advancing toward the mill is definitely and positively alined at right angles to the plane containing the axes of the mill rolls. The emerging material is in no wise obstructed but is gently received within a slightly tapering guiding throat. In both cases, the anti-friction rolls 37 prevent binding and insure continuous, steady forward movement of the material without grabbing or slipping. As before stated, the extreme positions of the inner ends of the guides may be adjusted initially by hand after disengaging the clutches 54. Thereafter, the range of movement of the inner ends of the guides is determined by the location of the detents 56 and stops 57. In the construction illustrated, I have assumed that one complete revolution of the shaft 39 will produce the necessary movement of the inner ends of the guides.

Figure 9 shows how the side guide actuators of Figure 1A are controlled. When the controller 185 is shifted so as to cause the material to be fed from left to right, it closes contacts 121. It will be understood that operation of the controller also, through appropriate relays, causes the starting of the motor 183 in the proper direction. The closing of the contacts 121 energizes an operating magnet 122 for a valve 123. This valve is similar to that shown at 181 of Figure 8. The energization of the magnet 122 operates the valve to the position illustrated in Figure 9, in which it delivers fluid under pressure to the inner ends of the cylinders 71 on the exit (left-hand) side of the mill, and to the outer ends of the cylinders on the entering (right-hand) side of the mill. The guides 36 on the entering side are thus closed in, as indicated in Figure 9, while the guides on the exit side are opened to permit free passage of the material as it emerges from the mill.

On the reversal of the direction of rolling, for the next pass, the controller 185 bridges contacts 124 and energizes a magnet 125 to shift the valve 123 to the other position. The reverse operation of the cylinder 71 then takes place to close the guides on the left-hand side and open the guides on the right-hand side.

It will be understood that only a single controller 185 is employed and that it controls contacts 119 and 124, for example, simultaneously, in addition to the other contacts necessary to bring the motor 183 up to operating speed. The system of Figure 9 is shown separately from that of Figure 8 simply because it is a diagrammatic plan, whereas the latter is a diagrammatic elevation, but it will be understood that the two systems are combined and under the common control of the controller 185.

* * * * *

The positive actuation of the side guides under the control of the main controller causes the strip to be properly started toward the mill and correctly positioned with respect thereto before it actually enters between the mill rolls, after which no effort is sufficient to correct an improper starting of the strip, because of the great force exerted on the strip by the rolls.

* * * * *

10. The combination with a rolling mill having a driving motor and a controller for the motor, of adjustable side guides on both sides of the mill, and means operated by said controller for shifting the guides inwardly on the entrance side of the mill and outwardly on the exit side of the mill.

Oct. 16, 1934. A P STECKEL 1,977,214

METHOD AND APPARATUS FOR HOT ROLLING STRIP METAL

Filed May 4, 1931

Fig. 1.

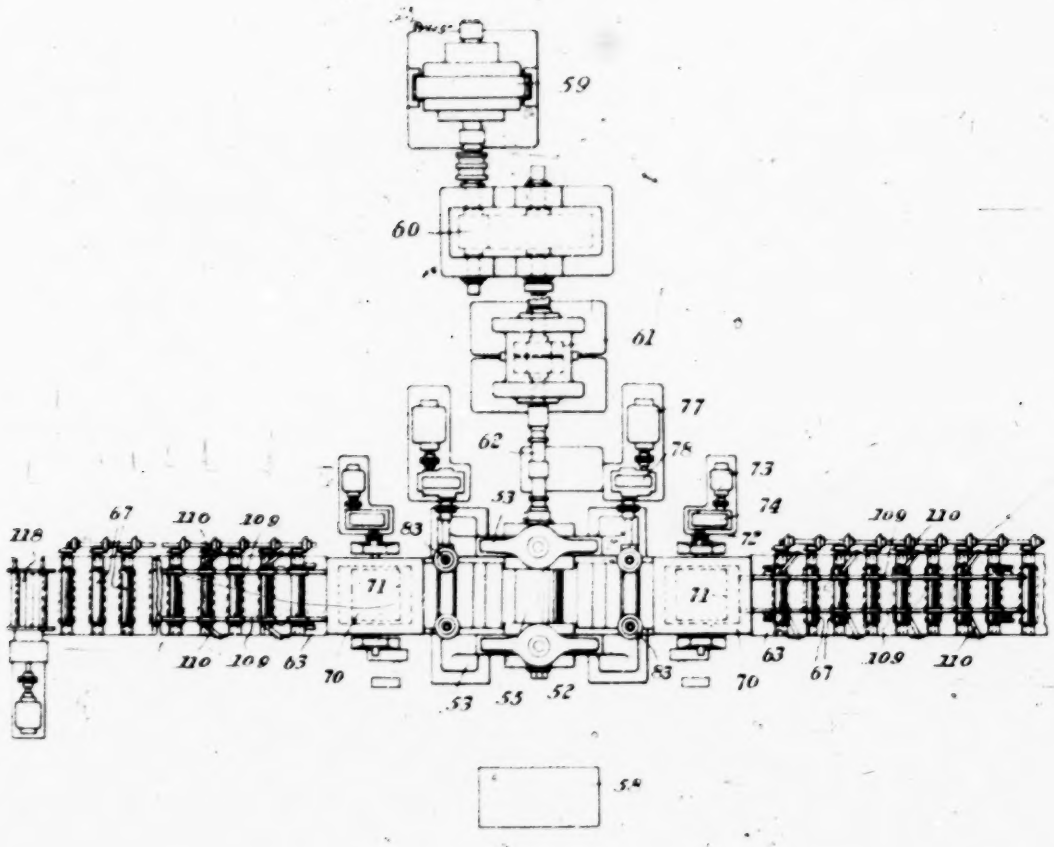
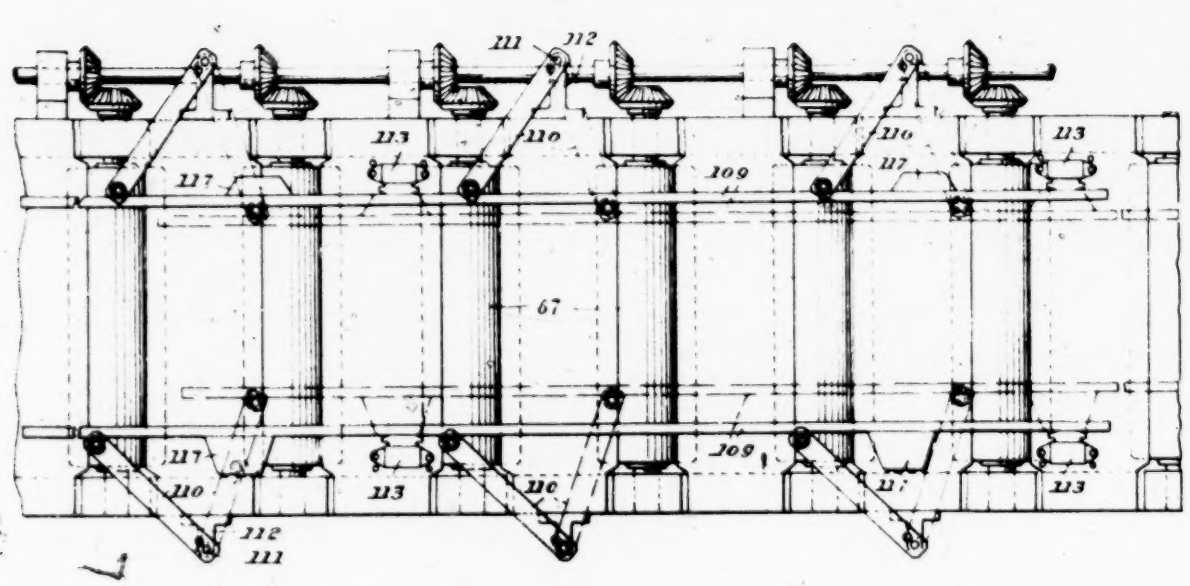


Fig. 6.



There are certain difficulties attendant upon rolling the material in the flat at the high speeds I contemplate, which difficulties must be overcome to make the installation desirable. As the material is reduced in thickness, it widens. In the early stages of rolling, where the slab is still relatively short, it is not so important that it be fed exactly squarely into the rolls, but as it increases in length its alinement becomes more and more important. In order to obtain such alinement, side guides must be employed, which side guides necessarily are spaced for entering the piece a distance only slightly more than the width of the piece being entered. On the exit side of the mill, however, the guides should have a relatively wider spacing in order to prevent cobbling. I provide automatically operable guides which fulfill these requirements.

* * * * *

The side guides comprise metal bars 109 connected to parallel links 110 pivoted at 111 on brackets 112 secured to the sides of the table. The bars 109 rest on the table rollers 67. The table shown in detail in Figure 6 lies at the left hand side of the mill as viewed in Figures 1 and 2, and the solid line position of the guides is their open position which is desired when receiving material. Assume now that a slab of metal to be rolled is lying on such table and it is desired to feed the same to the mill. The rolls 67 are rotated in such direction as to carry the metal to the right. By reason of the frictional engagement of the side guides 109 with the rollers, such guides are also carried to the right, swinging on the links 110. By reason of such movement they assume the position shown by dot and dash lines, and it will be noted that the guides in this position are much closer together and are effective for accurately alining the entering material. The further movement of the guides is limited by stops 113, which stops consist of casings 114 bolted to the mill table and carrying buffers 115 backed by coil springs 116.

When the rollers 67 are driven in the reverse direction the side guides are urged to the left as viewed in Figure 6 and swing back to the solid line position, their movement in this direction being limited by the side guides proper coming into engagement with the stops 113. The side guides are provided with pads 117 which engage the stops when the guides are at their inner position. The links 110 are provided with an extra hole or holes at their outer end through which they may be pivoted at 111 so as to vary their effective length and hence the spacing of the guides. The table is provided with a corresponding series of holes as shown in Figure 7, so that the stops 113 may be adjusted to correspond.

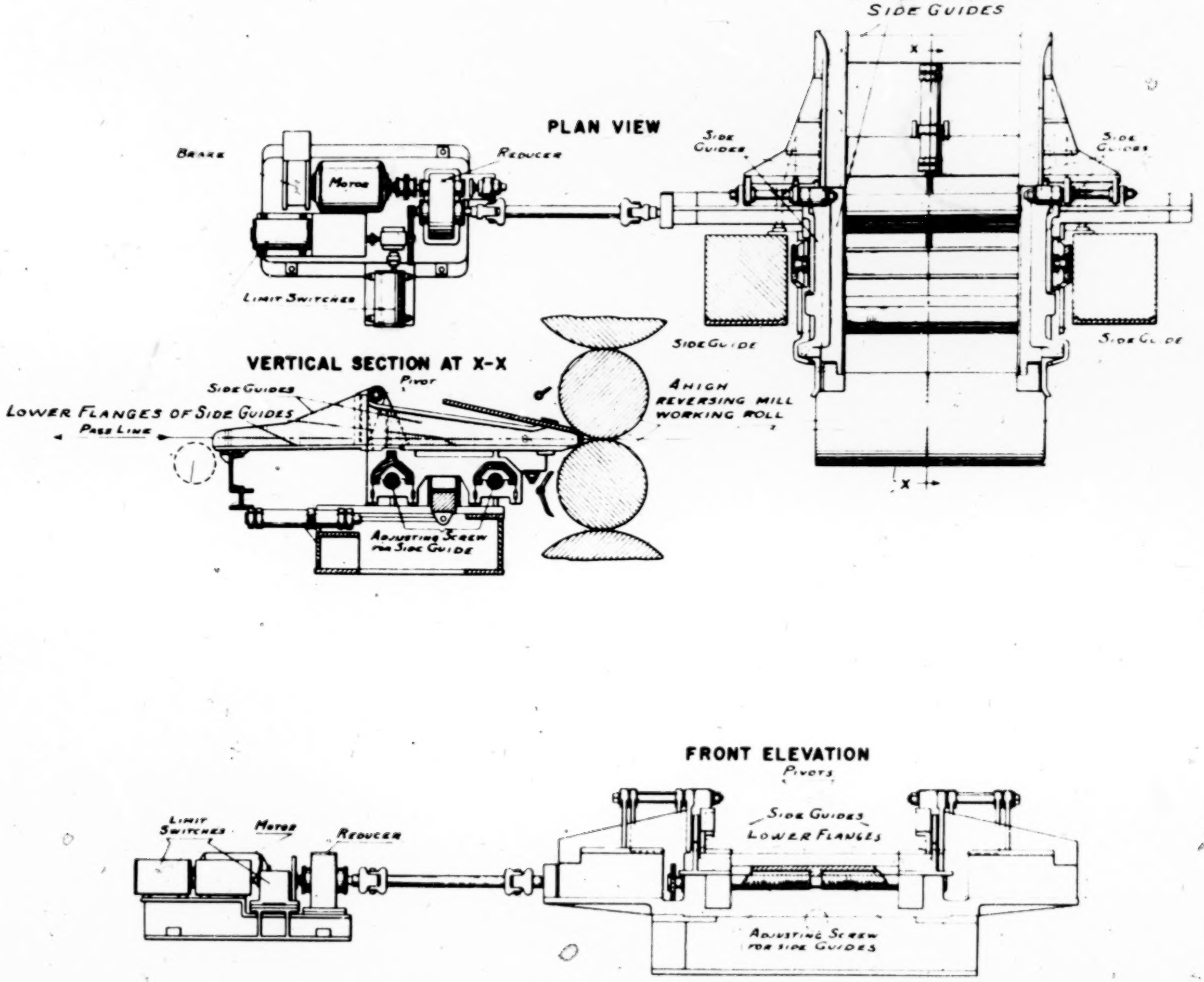
It will be noted that the initial angularity of the links on one side of the table differs from the initial angularity of the links on the other side of the table. The reason for this is that as the links move from the solid line to the dot and dash line position they move inwardly so long as the links are traveling toward a position of perpendicularity with respect to the axis of the table, and then slightly outwardly as the links move from such perpendicular position to their position of rest. If the initial angularity of the links on the two sides of the table were the same, such links might reach a condition of perpendicularity at the same moment, thus possibly bringing the guides so closely together as to interfere with the travel of the piece. However, this does not occur with the construction shown. On the contrary, the side guide shown at the upper portion of Figure 6 reaches its innermost position somewhat ahead of the guide on the opposite side. In so doing it engages the edge of the material and alines it. Then in coming to its position of rest it moves away from the material a slight distance so as to give it utter freedom of movement toward the mill, while limiting its sidewise movement to the slight clearance afforded by the travel of the links beyond their position of perpendicularity. The side guide shown at the lower portion of Figure 6 also engages the edge of the strip if the same is mis-alined, and thereby straightens it up for its travel into the mill.

* * * * *

6. In combination with a rolling mill, a table having rollers rotatable in either direction, a side guide movable on the rollers, and means for moving the side guide inwardly when the rollers rotate to move the guide in one direction and outwardly when they rotate to move it in the other direction.

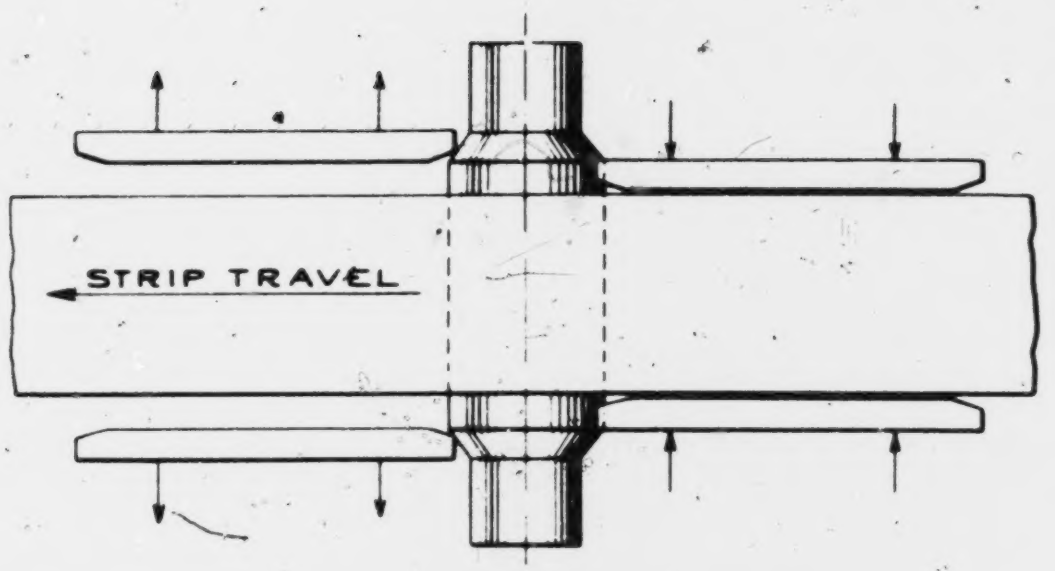
7. In combination with a rolling mill, a table having means for moving material therealong, and a side guide resting on the material moving means and movable therewith, means engaging the side guide arranged to move it laterally on actuation of the material moving means.

CRUCIBLE HOT STRIP MILL
SIDE GUIDE ASSEMBLY

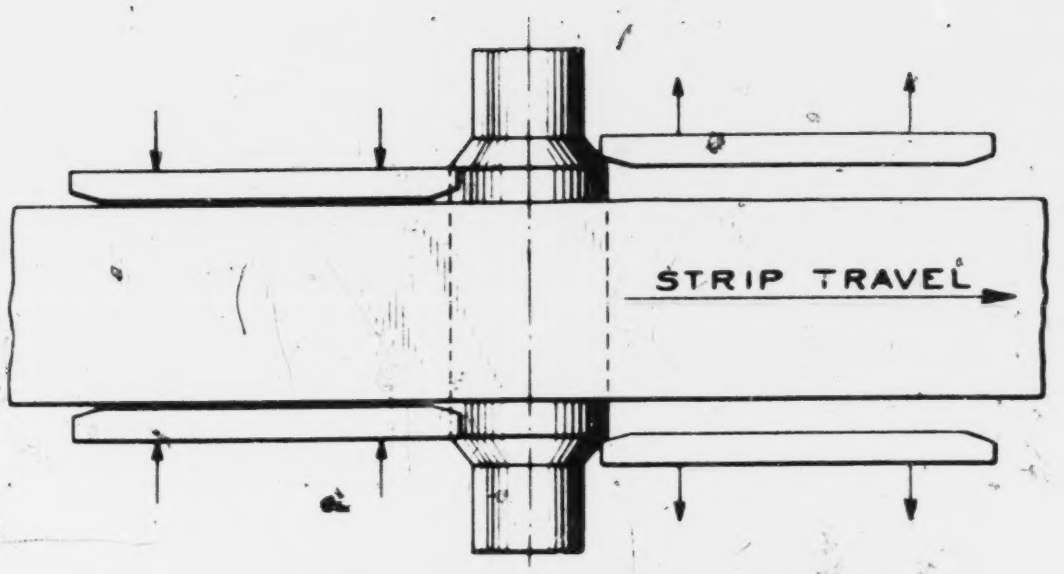


CRUCIBLE HOT STRIP MILL

SIDE GUIDE POSITIONS DIAGRAMATICALLY ILLUSTRATED



THREADING & RUNNING POSITIONS
TRAVEL TO LEFT



THREADING & RUNNING POSITIONS
TRAVEL TO RIGHT

EXHIBIT D-9

March 2, 1937. **A. B. MONTGOMERY** **2,072,122**

ROLLING MILL

Filed Dec. 4, 1934

Fig. 6.

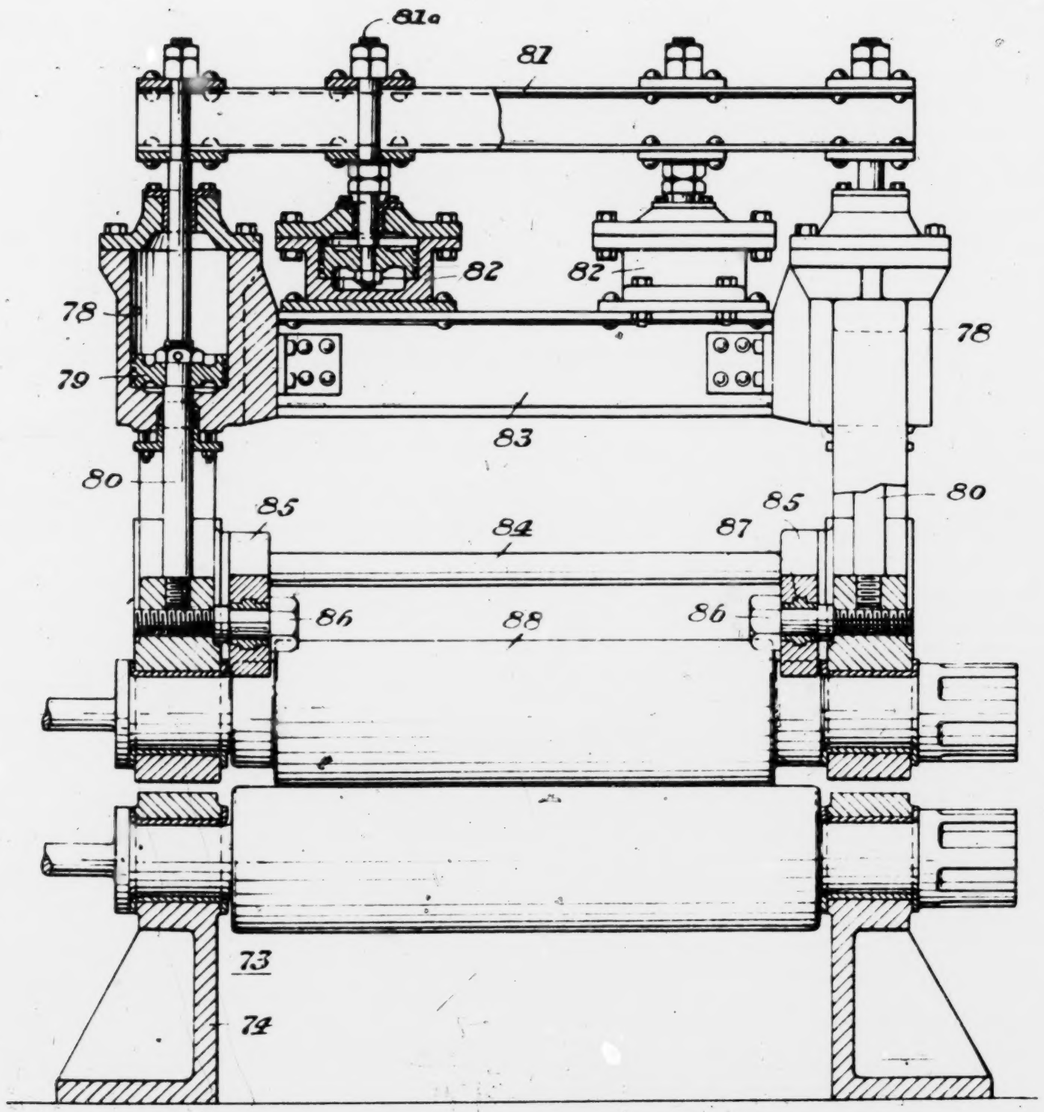
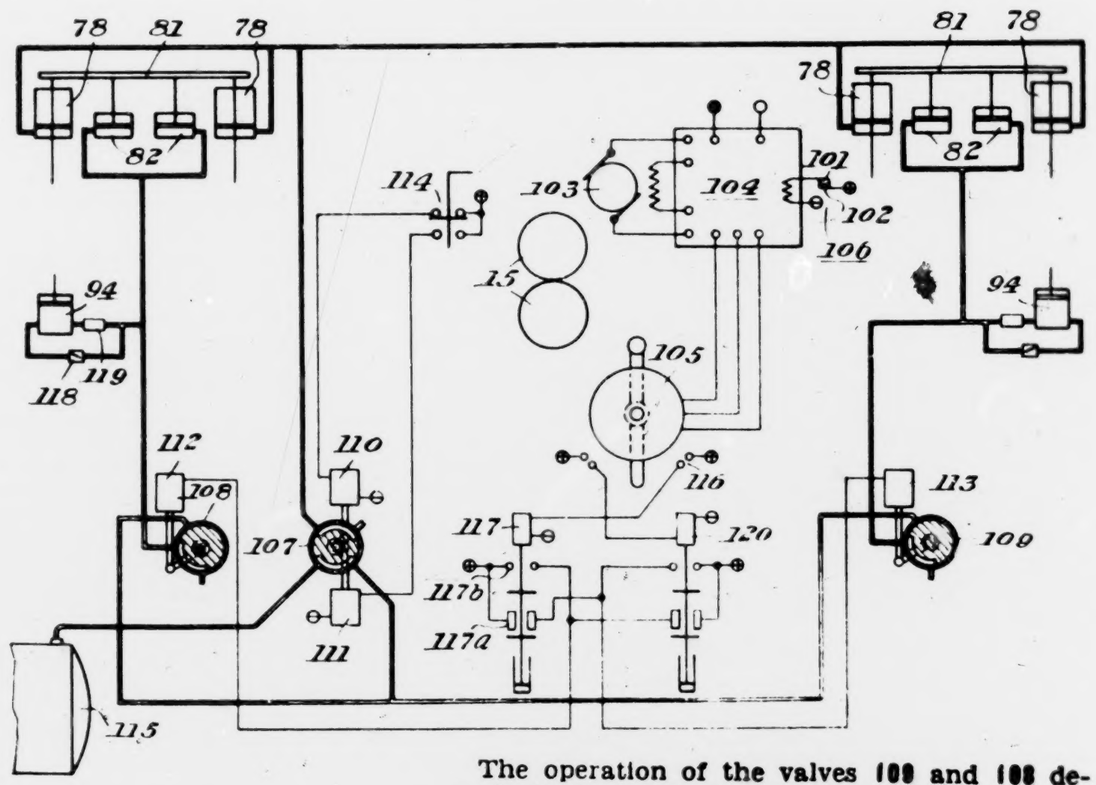


Fig. 8.



A modified form of construction of the auxiliary rolls for feeding and flattening the strip is shown in Figures 5 through 7. A roll table 73 has side frame castings 74. Housings 75 are attached to the castings 74 and have windows 76 therein in which bearing chucks 77 are slidable. Cylinders 78 formed in the upper part of the housings 75 have pistons 79 reciprocating therein. Piston rods 80 attached to the pistons 79 are threaded into the chucks 77 whereby the latter may be lifted to the dotted line position shown in Figure 5. Piston rods 80 extend outwardly through the upper end of the cylinders 78 and are connected by

When the thickness of the slab has been reduced to a point such that, on the next pass, the mill rolls are spaced apart only ¾" or less, the partially reduced material is sufficiently thinned and elongated to permit of coiling and, at the same time, its rigidity is such that the assistance of the pinch rolls is required to manipulate it through the mill and into the coilers. The limit switch 114 then closes its upper contacts to energize the magnet 110 and operate the valve 107 to the illustrated position. This vents the cylinder 78 and the pistons 79 immediately drop to lower the pinch rolls 88 onto the material. The pinch rolls are driven by any

The operation of the valves 108 and 106 described above, also causes the operation of the cylinders 94 on opposite sides of the mill. The roll 92 is thus raised into engagement with the material but is sufficiently spaced thereby from the roll 90 that the contact 101 remains in engagement with the contact 102. The fluid pressure is continuously applied to the cylinders 94 as long as the rolling continues but, unless the strip breaks during rolling, the rolls 90 and 92 are maintained separated and the contacts 101 and 102 remain in engagement. If the strip is broken, the roll 92 is immediately lifted into engagement with the roll 90, whereupon the rod 98 lifts the contact 101 to open the circuit for the relay 106 and thereby stop the motor 103.

When the pass is completed, the controller 105 is restored to neutral position so that the trailing end of the strip stops between the mill and the pinch rolls on the exit side thereof. The relay 117 is thus deenergized and substantially immediately opens its contacts to deenergize magnets 112 and 113. The cylinders 82 are thus exhausted to the atmosphere and the

A modified form of construction of the auxiliary rolls for feeding and flattening the strip is shown in Figures 5 through 7. A roll table 13 has side frame castings 14. Housings 15 are attached to the castings 14 and have windows 16 therein in which bearing chucks 17 are slidable. Cylinders 78 formed in the upper part of the housings 15 have pistons 79 reciprocating therein. Piston rods 80 attached to the pistons 79 are threaded into the chucks 17 whereby the latter may be lifted to the dotted line position shown in Figure 5. Piston rods 80 extend outwardly through the upper end of the cylinders 78 and are connected by cross beams 81. Cylinders 82 carried on a transom 83 extending between the housings, also have pistons and piston rods arranged as shown in Figure 6 whereby the beams 81 and, therefore, the chucks 17, may be raised through a small distance. The piston rods of the cylinders 82 have separable, abutting engagement with bolts 81a. It will be apparent that the cylinders 79 and 82 provide independent means for lifting the chucks 17 through a long stroke and a short stroke, respectively. The object of this arrangement will become apparent as the description proceeds.

An equalizing shaft 84 extends between the housings 15 and is journaled therein. Cranks 85 keyed to the shaft 84 carry trunnions 86 in slidable bearings blocks 87. The trunnions 86 are threaded into the chucks 17, as best shown in Figure 6. The equalizing shaft obviously serves to effect simultaneous and equal movement of both bearing chucks and prevents binding of the reciprocating mechanism.

* * * * *

The cylinders 79 and 82 are automatically controlled to cause the pinch rolls 88 and 89 to engage the material at certain times and to release it at other times.

In rolling a slab into strip on the mill 10, it is desirable that the pinch rolls 88 be withdrawn as long as the slab being reduced has sufficient rigidity to permit it to be fed back and forth to and from the mill by the friction of the table rolls. When the slab has been reduced to a gauge such that it has relatively little rigidity, or to a condition in which coiling between passes is advisable, the pinch rolls are advanced to assist in threading the strip through the mill at the beginning of each pass. While both ends of the strip actually pass through the mill, the pinch roll motors are so controlled that neither end of the strip is disengaged from the pinch rolls on both sides of the mill. At least one end of the strip is always engaged by at least one set of pinch rolls. It is by these pinch rolls that the strip is then fed back to the mill for the next pass. On the exit side of the mill, the pinch rolls assist in delivering the leading end of the strip into the coiler by pushing it up the guide 22.

* * * * *

When the thickness of the slab has been reduced to a point such that, on the next pass, the mill rolls are spaced apart only ¾" or less, the partially reduced material is sufficiently thinned and elongated to permit of coiling and, at the same time, its rigidity is such that the assistance of the pinch rolls is required to manipulate it through the mill and into the coilers. The limit switch 114 then closes its upper contacts to energize the magnet 110 and operate the valve 107 to the illustrated position. This vents the cylinder 78 and the pistons 79 immediately drop to lower the pinch rolls 88 onto the material. The pinch rolls are driven by any convenient means, at the same peripheral speed as the rolls 15, so as to cooperate therewith in moving the material back and forth.

If it is assumed for the sake of explanation that the breakdown formed from flat rolling the slab was reduced on a pass from left to right, to a gauge such that after the next reduction, it would be less than ¾" thick, as soon as the top roll 15 is lowered to within less than ¾" of the bottom roll, the described operation of the valve 107 will take place and the pinch rolls will seize the breakdown for the next pass from right to left. When all is ready for this pass, the roller operates the handle of the controller 105 to the left, as shown in Figure 8, whereupon the motor 103 is operated so as to drive the rolls 15 and roll the strip from right to left. The pinch roll drive is so coordinated with that of the mill that the pinch rolls 88 are simultaneously operated so as to assist in the feeding of the breakdown.

The movement of the controller 105 bridges contacts 116 to energize a relay 117. The relay 117 has a time delay in its operation, indicated by a dashpot, and after a certain time bridges contacts 117a to energize the magnet 113. The relay is adjusted so that the contacts 117a will be bridged just after the leading end of the breakdown being rolled passes between the rolls 15. The magnet 113 operates the valve 109 to admit fluid supplied through the valve 107 to the cylinders 82 on the entering side of the mill. The pinch roll 88 on that side is thus lifted from the material.

After a slightly longer time, the relay 117 operates to bridge its contacts 117b, maintaining the circuit for the magnet 113 by reason of the fact that the bridging contact slides along the contacts 117a. The relay is adjusted so that the contacts 117b are bridged after the material has emerged from the mill on the exit side, passed through the pinch rolls, and made one turn about the coiler. The bridging of the contacts 117b causes the operation of magnet 113 to shift the valve 108. The cylinders 82 on the exit side of the mill thus operate to raise the associated pinch roll from the strip. The strip is thus free between the winding and unwinding coilers, except where engaged by the mill.

94 as long as the rolling continues but, unless the strip breaks during rolling, the rolls 90 and 92 are maintained separated and the contacts 101 and 102 remain in engagement. If the strip is broken, the roll 92 is immediately lifted into engagement with the roll 90, whereupon the rod 98 lifts the contact 101 to open the circuit for the relay 106 and thereby stop the motor 103.

When the pass is completed, the controller 105 is restored to neutral position so that the trailing end of the strip stops between the mill and the pinch rolls on the exit side thereof. The relay 117 is thus deenergized and substantially immediately opens its contacts to deenergize magnets 112 and 113. The cylinders 82 are thus exhausted to the atmosphere and the pinch rolls dropped. At the same time, the cylinders 94 are exhausted through check valves 118, the weight of the roll 92 and chucks 93 serving to force the accumulated fluid out of the cylinders. The operating fluid for the cylinders 94 passes initially through expansion valves 119 which slightly delays the lifting of the chucks 93 on starting a pass.

The next pass is accomplished in exactly the same manner. Reversal of the controller 105 energizes the relay 120 and this, in turn, causes sequential lifting of the pinch rolls 88 on the entering and exit sides of the mill. This cycle is repeated until the strip has been reduced to the desired gauge, when it is wound on a coiler beyond the furnace on the exit side of the mill. The top work roll is then lifted by reversal of the screwdowns. The switch 114 closes its lower contacts and operates the valve 107 to admit fluid under pressure again to the cylinders 78, whereby the pinch rolls 88 on both sides of the mill are lifted out of the way for the next flat rolling operation.

* * * * *

6. In a rolling mill including a pair of housings and work rolls journaled therein, pinch rolls on one side of the mill, and means for raising one of the pinch rolls through a short distance, and independent means for raising the upper pinch rolls through a greater distance.

18. In a rolling mill, a pair of housings having work rolls journaled therein, pinch rolls on at least one side of the mill for engaging material being worked in the mill, means for retracting one of said pinch rolls when unused for a substantial period, and independent means for temporarily retracting one of said rolls.

19. The combination with a rolling mill and a roll table for advancing work thereto, of pinch rolls on one side of the mill, one of said pinch rolls being retractible, and means for retracting said roll including fluid pressure-operated cylinders and pistons, one of which has a short stroke for temporarily retracting the roll and the other having a longer stroke for retracting the roll when unused for substantial periods.

Oct. 16, 1934. A. P. STECKEL 1,977,214

METHOD AND APPARATUS FOR HOT ROLLING STRIP METAL

Filed May 4, 1931

(D-9, 2)

Fig. 4.

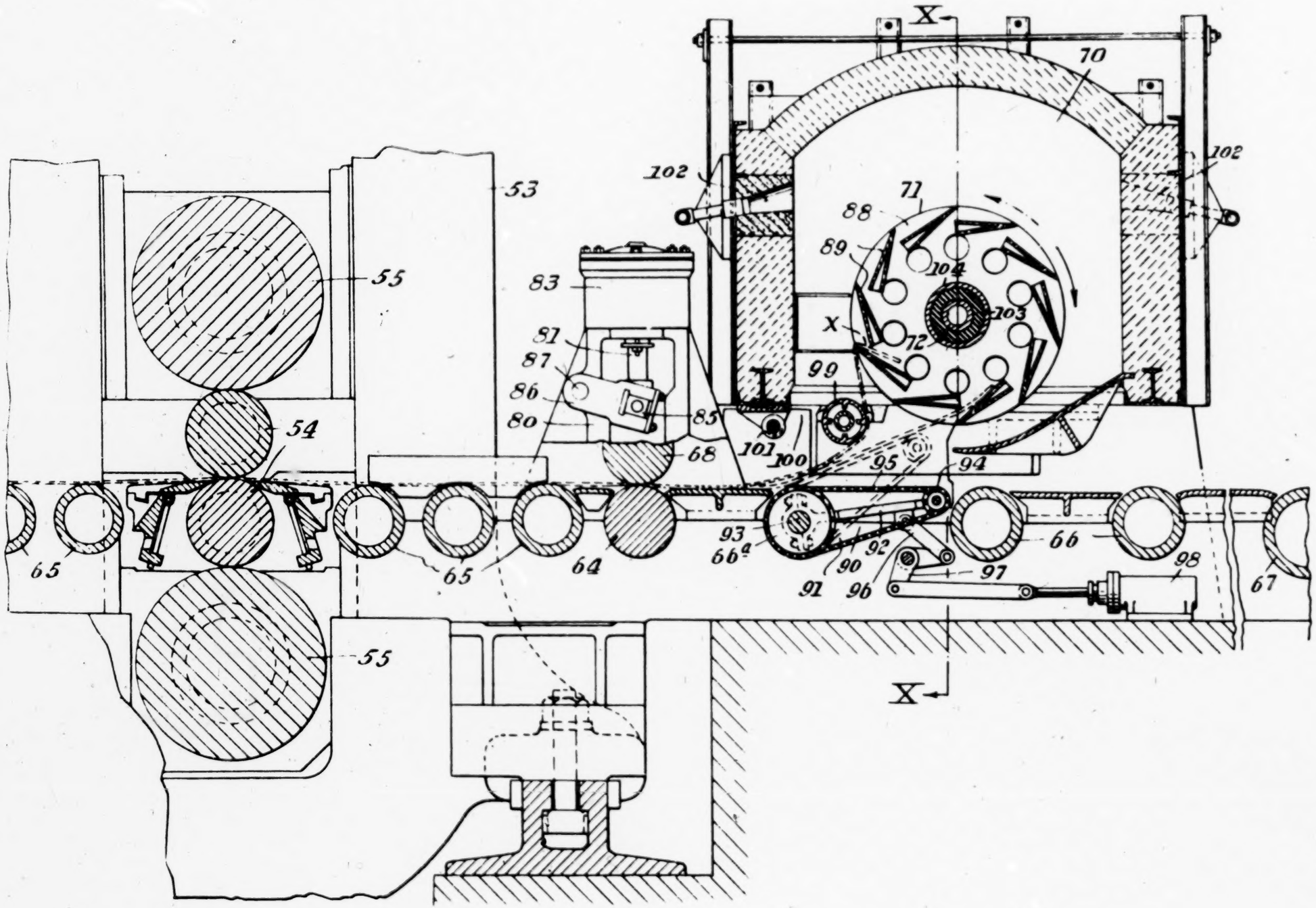
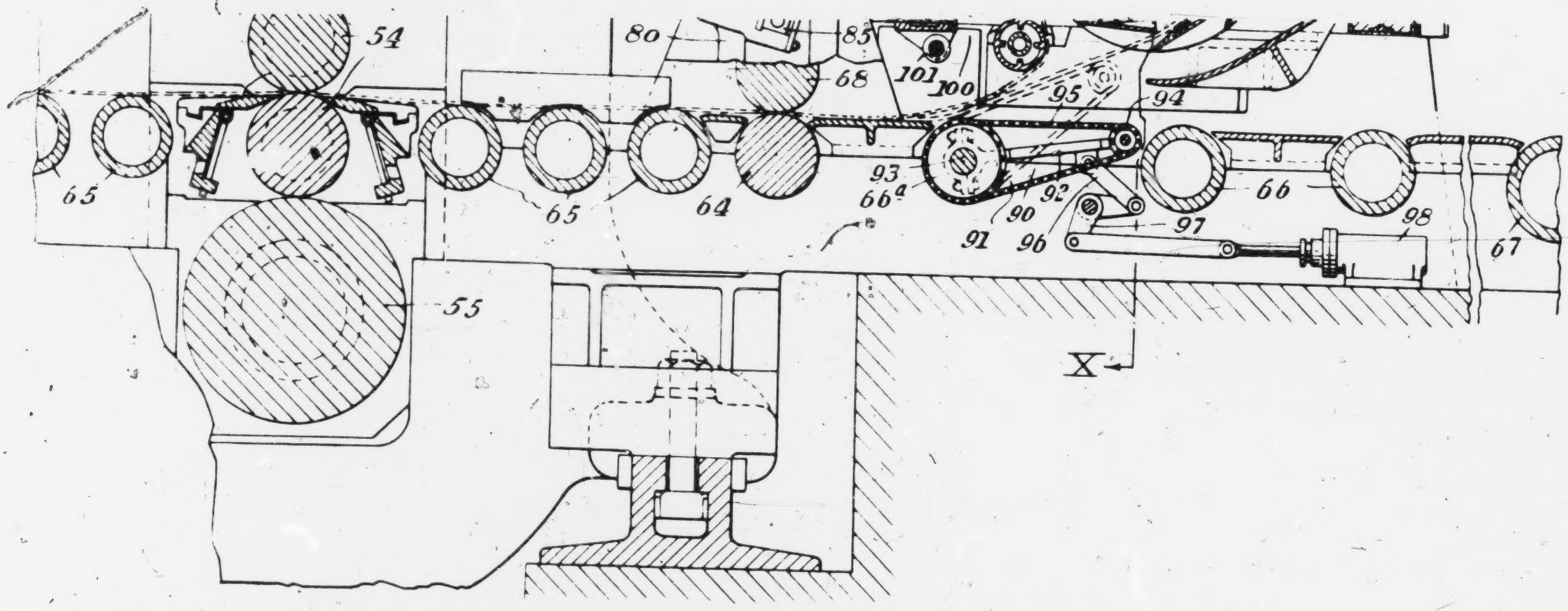


EXHIBIT D-9

**4-Panel Fold-out Chart re Double Lift Pinch Roll,
Claims 6, 18 and 19 of Montgomery 122**



The pinch rolls operate to maintain the material under tension and this is highly desirable. It insures straightness of the product and materially simplifies the handling. The pinch rolls on the exit side will be arranged to exert a forward pull on the material, and those on the entering side will be arranged to impart a drag thereto. This causes the material to issue straight. If there are any slight irregularities due to over-rolling at one point or another across the width of the strip, such irregularities will be largely or entirely removed.

* * * * *

The rolls 64 cooperate with rolls 68 to form a pinch roll unit effective for engaging material. The rolls 68 are arranged to be raised or lowered as desired

The pinch roll structure is best illustrated in Figures 4, 8 and 9. The rolls 64 are driven through coupling boxes 75 and spindles 76 from motors 77 (see Fig. 1) through reducing gears 78. The motors 77 are controlled from the operator's pulpit 58 as are the motors 73 and 59.

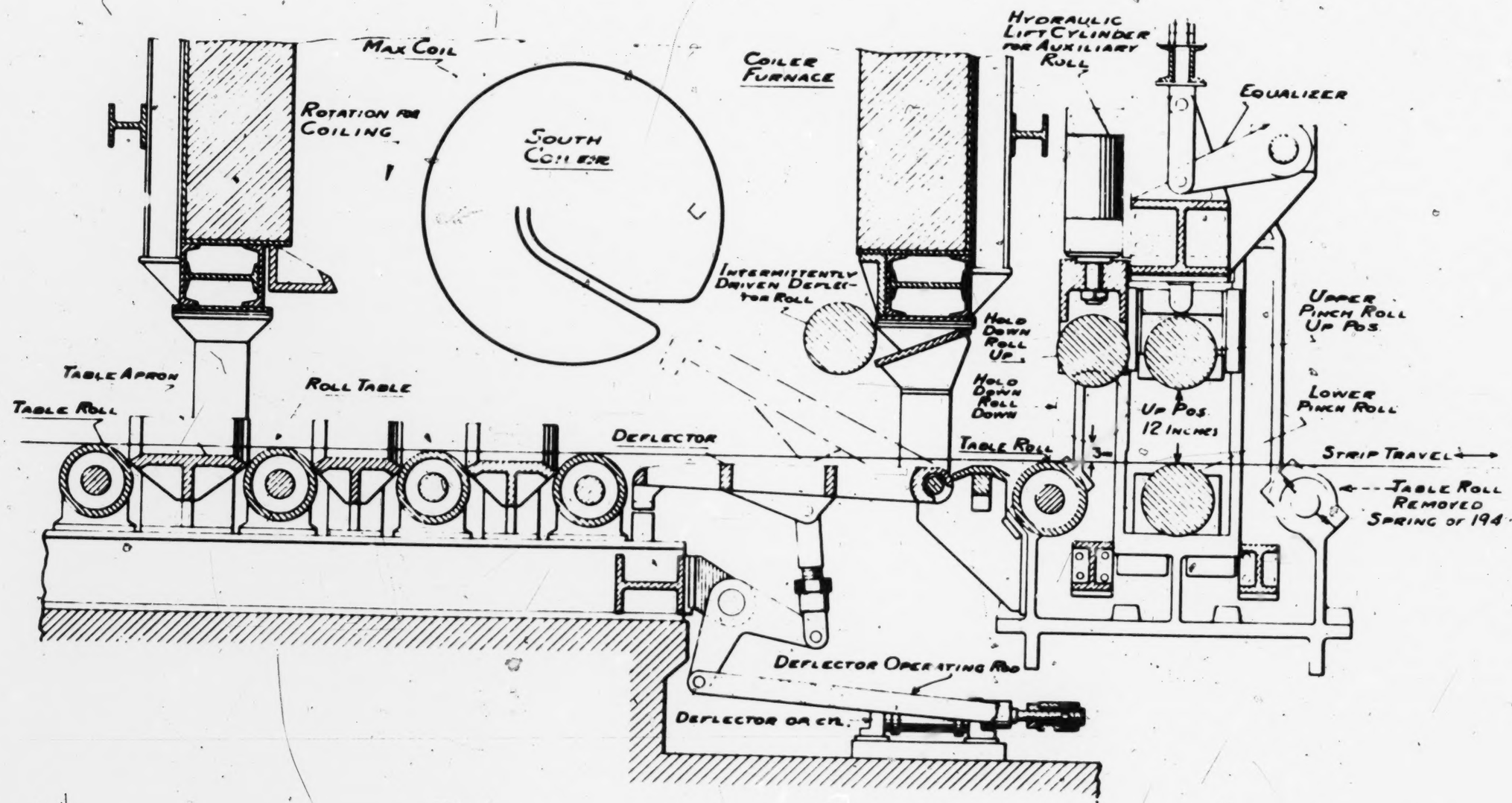
The rolls 68 are mounted in bearings 79 slidable in housings 80. A piston rod 81 extends upwardly from each bearing 79 to a piston 82 in a cylinder 83 formed in the upper part of the housing 80. The pistons 82 may be raised or lowered by controlling the supply of air to the cylinders 83. The movement of the cylinders is also controlled from the operator's pulpit 58. In order to insure simultaneous raising and lowering of the bearing 79 for each end of a roll 68, the bearings are interconnected. Each bearing carries a stud 84 extending through a block 85 slidable in the forked end of a lever 86. The levers 86 are keyed to a rocked shaft 87 so that the bearings 79 are bound to move up or down together.

CRUCIBLE HOT STRIP MILL

VERTICAL SECTION AT PINCH ROLL & COILER

MODIFIED INSTALLATION

(D-9, 3)



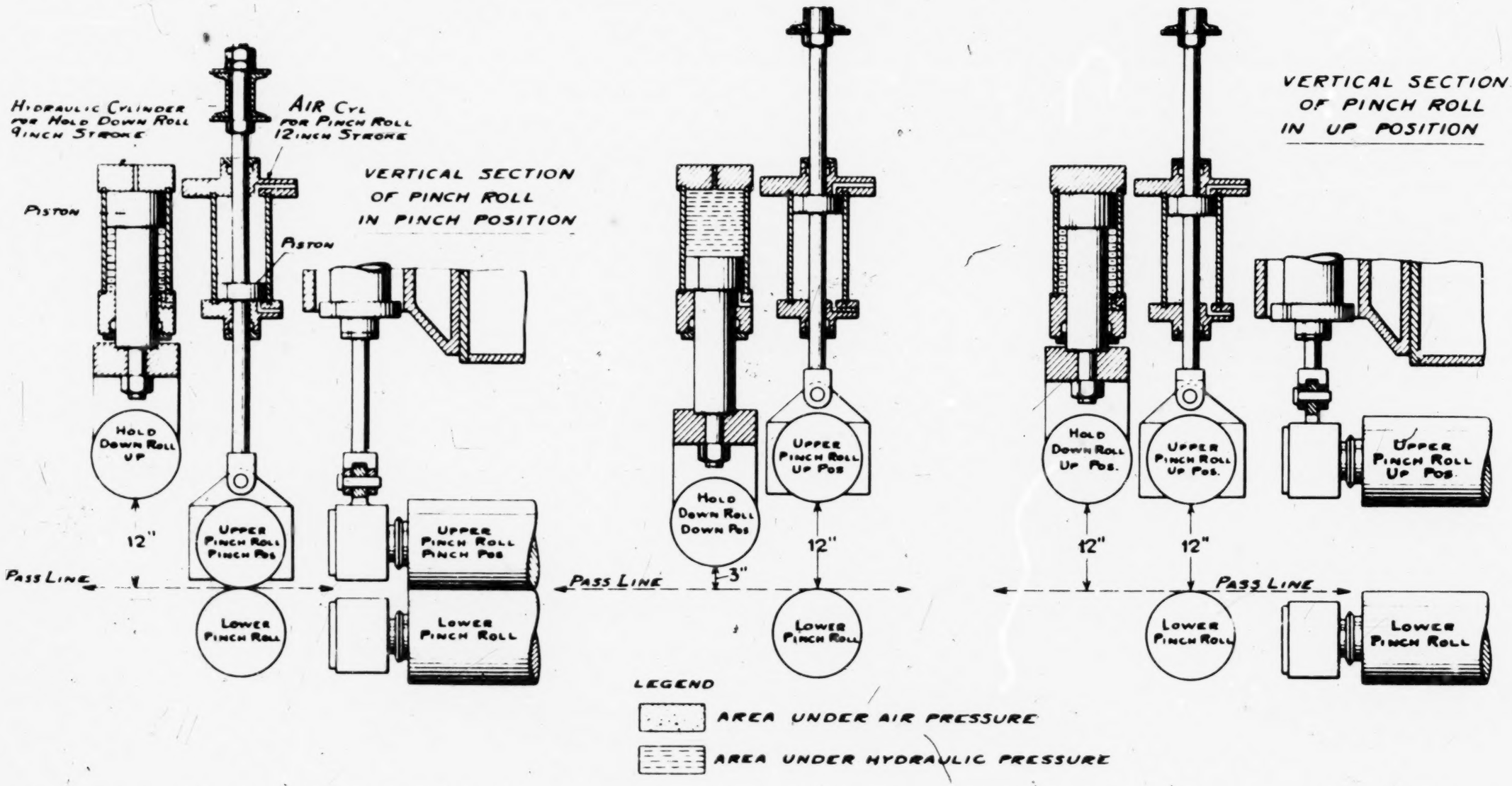
CRUCIBLE HOT STRIP MILL

PINCH ROLL & AUXILIARY ROLL ARRANGEMENT

MODIFIED INSTALLATION

A9

(D-9,2,4)



LEGEND

AREA UNDER AIR PRESSURE

AREA UNDER HYDRAULIC PRESSURE

EXHIBIT D-10

5-Panel Fold-out Chart re Claims 4 and 6 of Montgomery 107

(Acc 1 of 15)

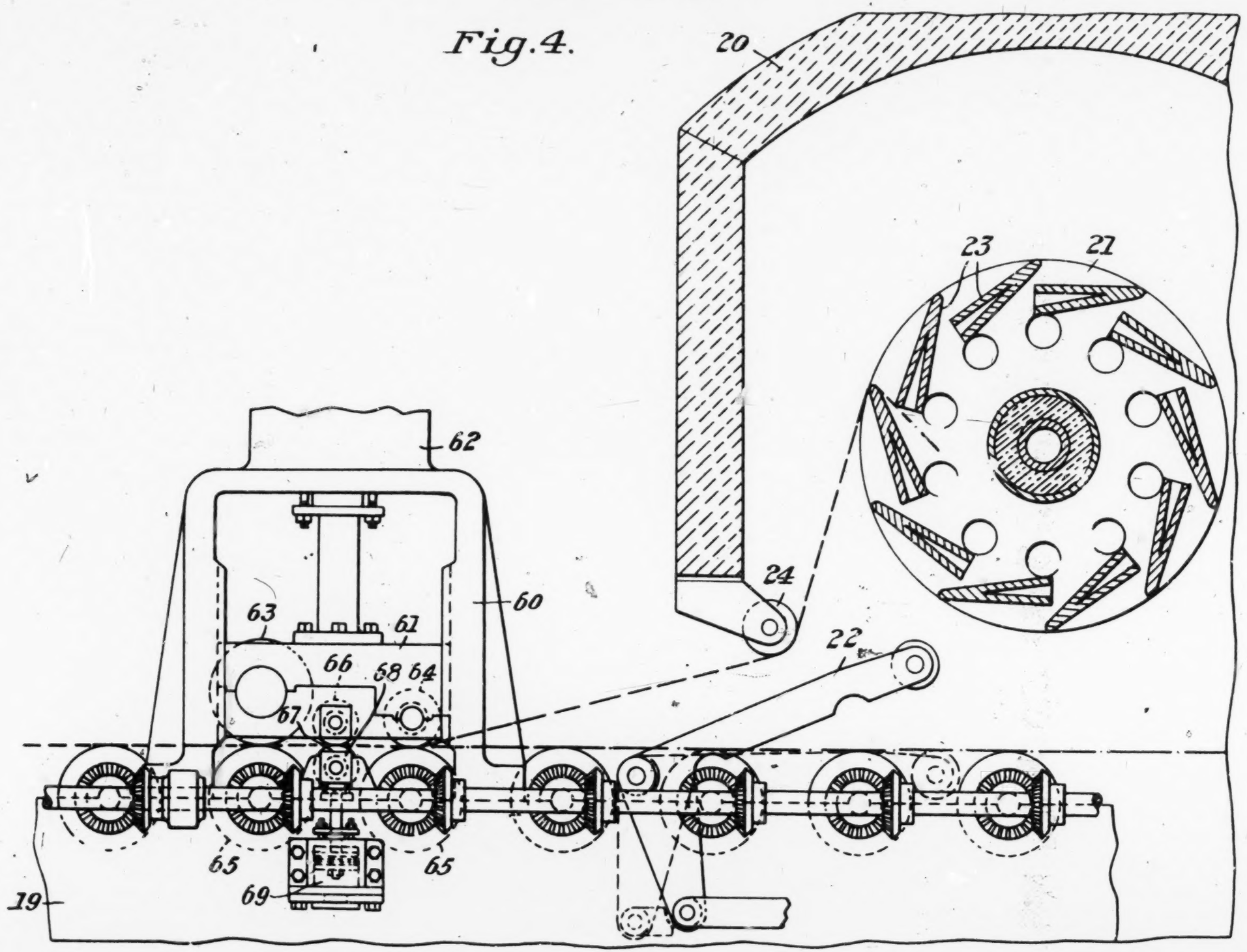
EXHIBIT D-10

Sept. 10, 1940. **A. B. MONTGOMERY** **2,214,107**

METHOD OF ROLLING

Filed Oct. 23, 1936

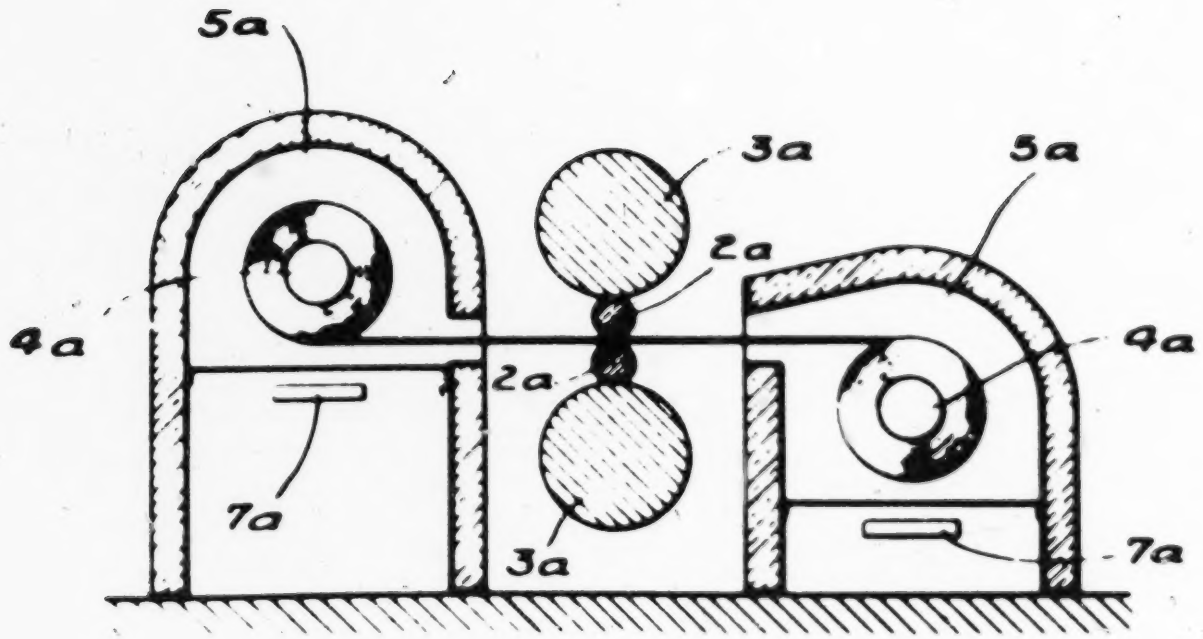
Fig. 4.



May 10, 1932. A P STECKEL 1,857,670

ROLLING METAL STRIP

Filed June 15 1927



July 18, 1933. R. M. KEENEY ET AL 1,918,968

ROLLING MILL

Filed Jan. 12, 1928

FIG. 1.

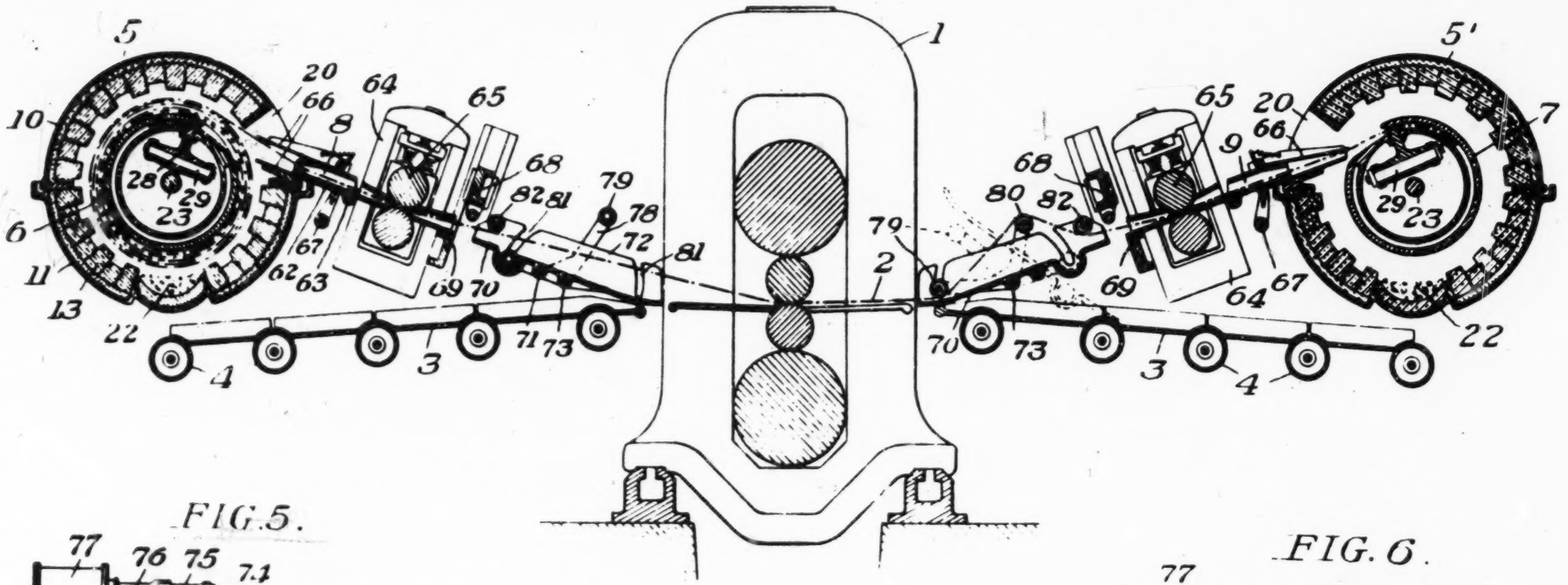


FIG. 5.

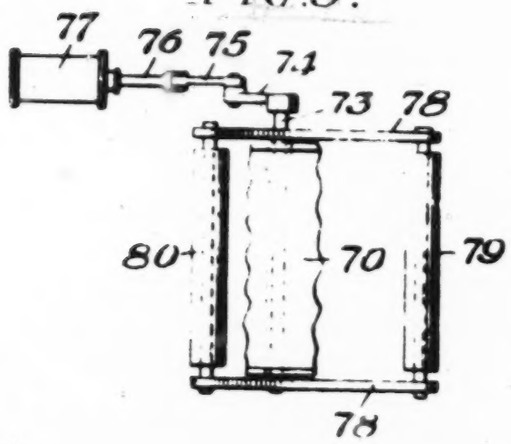
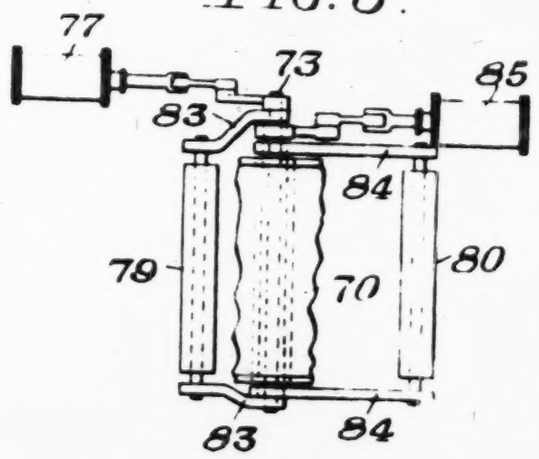


FIG. 6.

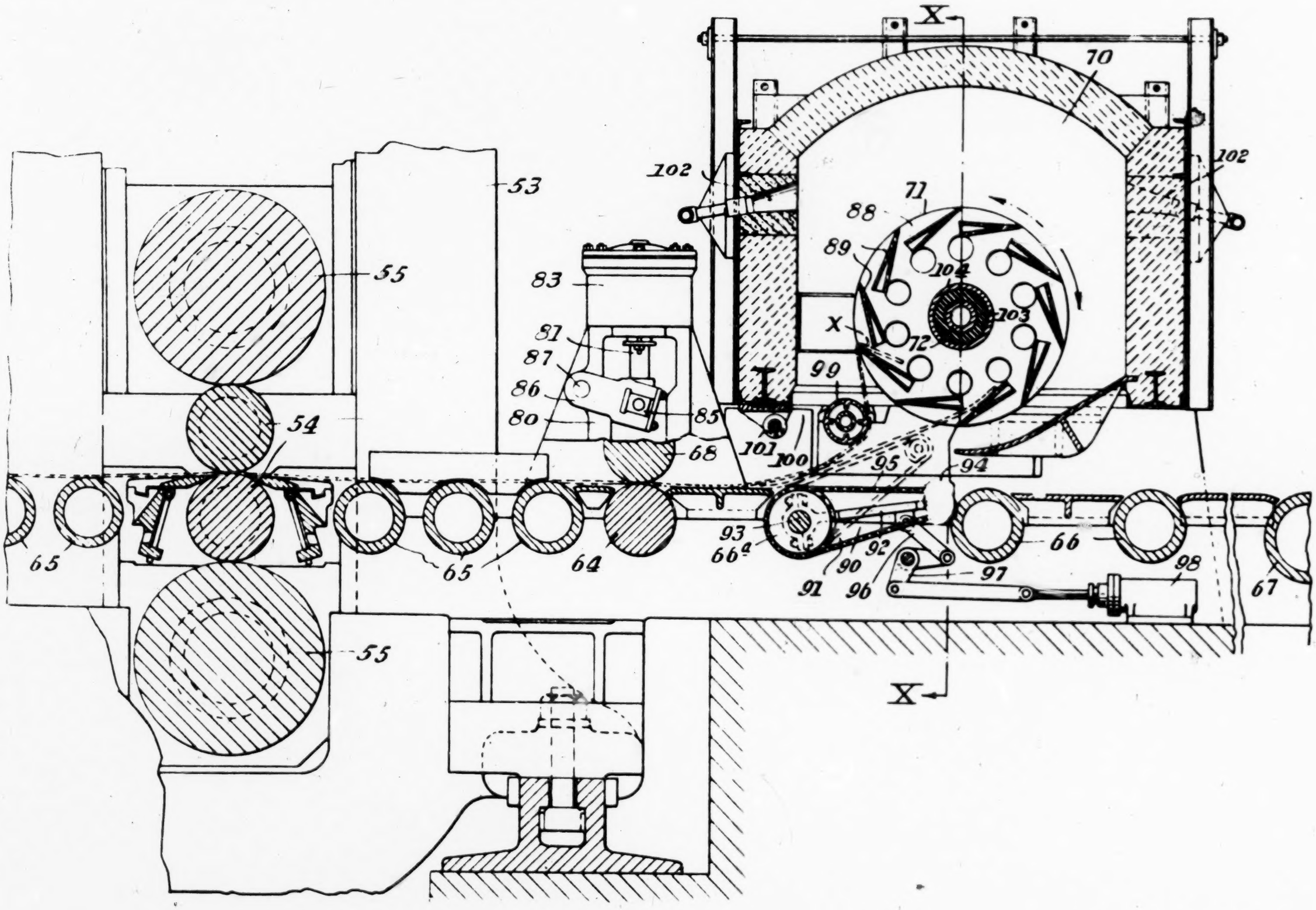


Oct. 16, 1934. A. P. STECKEL 1,977,214

METHOD AND APPARATUS FOR HOT ROLLING STRIP METAL

Filed May 4, 1931

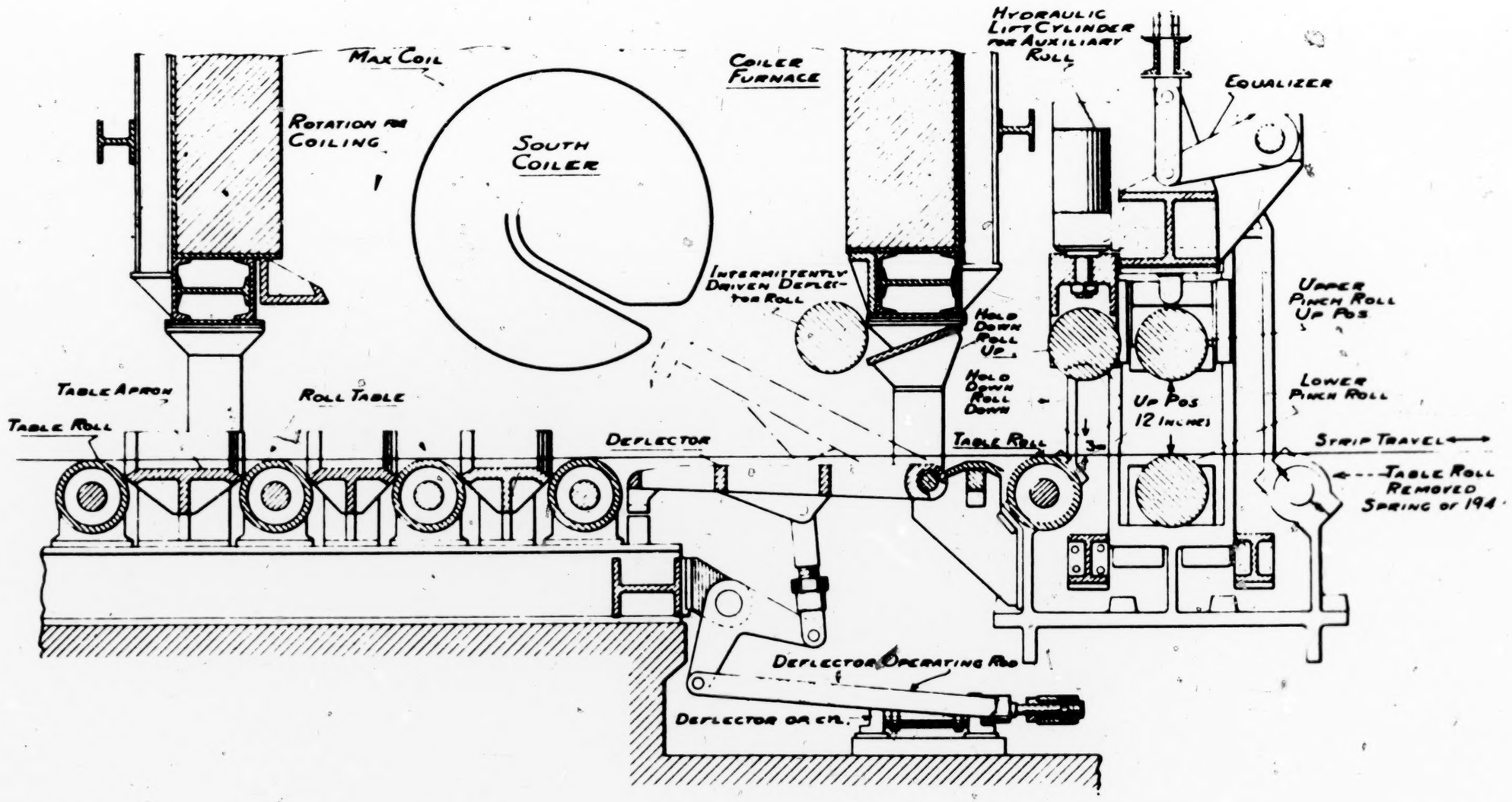
Fig. 4.



CRUCIBLE HOT STRIP MILL

VERTICAL SECTION AT PINCH ROLL & COILER

MODIFIED INSTALLATION



In my copending Patent 2,072,122, I have described and claimed a mill which is an improvement over those of the types shown in United States patents to Keeney et al. No. 1,918,968 and Steckel No. 1,977,214, including guides on both sides of the mill which, while operating on the principle described and claimed in the first mentioned copending application represent a structural improvement over the latter. Beyond the guides, pinch-rolls are disposed and coiling reels are mounted within heating furnaces, in the general manner shown in the patents referred to. In accordance with the present invention, however, I utilize the pinch-rolls only while starting the leading end of a breakdown through the mill and into the coiling reel on the opposite side, the pinch-rolls being thereafter retracted, freeing the strip between the mill and the reel. I then apply sufficient torque to the shaft of the winding reel to tension the portion of the breakdown between the reel and the mill. I also apply a back tension to the portion of the breakdown between the mill and the unwinding reel thereby exerting a retarding torque on the shaft of the latter. By thus tensioning the breakdown, I am able to form a tight coil on the winding reel, thus eliminating "skidding" and preventing cambering of the product during the later rolling passes.

* * * * *

These shafts are normally driven from extensions 50 of the shaft of one of the rolls 51 of the table 19. The rolls of the table are driven from a line shaft 52 through the usual bevel gears by a reversing motor, not shown. Between the shaft extensions 50 and the shafts 48 are positioned friction clutches 53 and jaw clutches 54 having operating levers 55.

* * * * *

The rolls 63 and 65 may be driven and when the former is lowered into engagement with the latter, they serve as pinch rolls to feed the strip toward the mill from the coiler 21. When the strip has been started through the mill and engaged the coiler on the opposite side thereof, the chucks 64 are preferably raised and the rolls 63, 64 and 66 lifted off the strip.

* * * * *

The cylinders 82 on the exit side of the mill thus operate to raise the associated pinch roll from the strip. The strip is thus free between the winding and unwinding coilers, except where engaged by the mill.

* * * * *

As soon as the leading end of the breakdown has been engaged by the coiling reel, and the pinch rolls retracted, I cause the motor 21*a* driving the coiling reel to exert thereon a torque sufficient to impart tension to the breakdown between the coiling reel and the mill. At the same time, I operate the motor 21*a* connected to the unwinding reel as a generator, to impart a back tension to the portion of the breakdown between the uncoiling reel and the mill. The torques exerted by the motor and generator are preferably maintained constant by any convenient means such as current regulators effective to maintain constant currents through the armatures of the motor and generator. The relationship of the regulators to the motor and generator is reversed on reversal of the mill, the regulator for the coiling-reel motor, obviously, being set for a greater current than the regulator connected to the uncoiling-reel generator.

By this provision, I tension the breakdown on the exit side of the mill between the mill and coiling-reel. On the entrance side, the breakdown is tensioned between the mill and the uncoiling-reel.

* * * * *

The automatic control of the pinch rolls on both sides of the mill insures that the strip will be advanced properly into the mill and, on emerging therefrom, into the coiler, whereupon the pinch rolls will be lifted out of the way when there is no further need for them.

* * * * *

4. In a method of converting a slab or ingot into strip, the steps including passing a slab back and forth in the flat between reducing rolls to form a breakdown, passing the breakdown back and forth between reducing rolls to form a strip, winding the breakdown on a coiling reel between passes through the rolls, bending the breakdown about a guide roll, and driving said guide roll to prevent frictional drag on the breakdown.

* * * * *

6. In a method of rolling strip, the steps including passing a breakdown, heated to plastic condition, back and forth between reducing rolls, uncoiling it on one side and coiling it on the opposite side of the rolls, passing an end of the breakdown entirely through the rolls, frictionally gripping said end to feed it back through the rolls, freeing that portion of the breakdown between the mill and the point of coiling, and tensioning such portion uniformly throughout.

7. In a method of making strip by passing a breakdown, heated to plastic condition, through reducing rolls, coiling the strip on the exit side, uncoiling it from a previously formed coil on the entrance side of the rolls, gripping the strip at points between the rolls and points of coiling only long enough at the beginning of each pass to thread the end of the breakdown through the rolls and start coiling thereof on the exit side, and then freeing the breakdown between the rolls and the points of coiling, while continuing to pass the strip through the mill in the same direction.

8. The method defined by claim 7 characterized by tensioning the portion of the breakdown between the rolls and the point of coiling uniformly throughout to cause the breakdown to coil straight and true.

Metal strip is now being rolled in continuous mills, but these mills are so large and occupy so much space that a very heavy capital outlay is required. The operating cost of the continuous mill is high because of the large amount of power required.

* * * * *

Coilers 4*a* are provided on either side of the mill, these being arranged to reel or to pay out material depending on which way the mill is running. Each coiler is motor driven and may be operated at such a rate as to maintain the delivered strip under tension.

* * * * *

2. The method of rolling metal strip which includes coiling a strip of hot metal in a heating chamber, uncoiling the same and feeding it from the chamber through a roll pass and to another heated chamber, coiling the strip therein in a direction opposite to that in which it was first coiled, periodically reversing the direction of rolling, and maintaining the metal under tension between the rolling thereof and the coiling thereof.

Figures 5 and 6 show alternative means for maintaining tension upon the strip.

* * * * *

To act as a drag upon the reel during unwinding we provide a band-brake 61 of common form for the shaft 23, having its free end counterweighted, so as to operate only when the shaft is turning in the unwinding direction. This brake is shown in Figures 2 and 3.

* * * * *

Tension is maintained yieldingly upon the looped strip, as shown in Figure 1, by means of the fluid-pressure cylinders, and the size of the loop aids the operator in adjusting the speed of rotation of the reel in the coiler to the speed of the reducing rolls.

* * * * *

In operation, assuming that the table 3 at the right-hand side of Figure 1 leads from the roughing mill, the roughed-down strip will be carried on this table into and through the initial pass between the reducing rolls 1, which also act to feed the strip up the chute at the left and between the pinch-rolls, which are being driven at that time and which feed the strip on into the coiler, the guide 62, 66 being in advanced position to direct the leading end of the strip into the slot 25 in the reel. As soon as the leading end of the strip enters the slot 25 it is locked by the bar 28, and the coiler-motor is started and the strip is wound on the reel, the pinch-roll motor being stopped and the driving-shaft disconnected by opening of its magnetic clutch, so that during the winding operation the pinch-rolls act as idle guide rollers.

* * * * *

During this reducing operation the pinch-rolls at the left turn idly, and the reducing rolls unwind the strip, the unwinding speed of the reel 6 being controlled by the drag-brake 61.

* * * * *

In the introductory part of this specification we have described this invention as particularly applicable to the hot rolling of iron or steel strips or strip sheets of light gauge and of great length. Heretofore in the art the term "strip" has been used to designate a long, thin piece of metal which is comparatively narrow, say of a maximum width of sixteen inches. Our invention is not limited to the manufacture of such pieces, but it is the intention to cover in the appended claims the manufacture of long, thin pieces of metal of any practicable width, and designated by us generally (whether narrow or wide) as thin metal strips.

The pinch rolls operate to maintain the material under tension and this is highly desirable. It insures straightness of the product and materially simplifies the handling. The pinch rolls on the exit side will be arranged to exert a forward pull on the material, and those on the entering side will be arranged to impart a drag thereto. This causes the material to issue straight. If there are any slight irregularities due to over-rolling at one point or another across the width of the strip, such irregularities will be largely or entirely removed.

EXHIBIT D-21

YEAR BOOK

OF THE

American Iron and Steel Institute

1927

MAY MEETING - - - - - - - - NEW YORK
OCTOBER MEETING - - - - - - NEW YORK

Published by the
AMERICAN IRON AND STEEL INSTITUTE
[illegible] New York

Copyright, 1928, by
AMERICAN IRON AND STEEL INSTITUTE

PRINTED IN THE U S A BY
J B LIPPINCOTT COMPANY
PHILADELPHIA PA

THE EVOLUTION OF THE WIDE STRIP MILL

STEPHEN BADLAM
Consulting Engineer, Pittsburgh, Pa.

The outstanding achievement of the present decade, in the history of the rolling mill, is the development in the art of rolling wide, thin sections, as exemplified by the wide strip mill and the continuous sheet mill.

The rolling of wide, thin sections has developed along two distinct and originally widely separated lines.

First: the rolling of strip, characterized by limitations in width and gage, rather than in length.

Second: the rolling of sheets, characterized by limitations in length, rather than in width and gage.

In 1924 strip was obtainable in widths up to 24 inches and in lengths as long as were demanded. Sheets were obtainable in widths as wide as were demanded (to about 54 inches) but were limited in length.

Strip was produced from billets and slabs, and in units from 100 pounds up to 2000 pounds in weight, and was finished at delivery speeds up to 1000 feet per minute.

Sheets were produced from sheet bars, and in units from 12 pounds up to 70 pounds in weight, and were finished at delivery speeds of about 240 feet per minute.

Strips were always rolled single, while sheets were generally rolled in "packs."

In the year 1924 a sheet mill was placed in operation that produced sheets by a continuous process, in widths up to 45 inches and in lengths up to 30 feet. In 1927 a product was placed on the market, in widths up to 36 inches, having characteristics of both strips and sheets, but without the previously existing dimentional limitations of either. This new product approximates to strips in length, to sheets in width, and to both, in gage and physical characteristics. For the purposes of this paper it will be designated by the term

as well as blue annealed sheets, in widths up to 48 inches and in gages from 6 to 16 inclusive, in addition to the rough sheets produced for further reduction to lighter gages in the sheet mill.

The production of the Ashland Plant was over 24,000 tons in both May and June of the present year, and this was limited, not by the capacity of the mill, but by the open-hearth production. Two more furnaces are now being added and it is not expected that this will give a production in excess of the capacity of the mill to handle it. Of the 24,000 tons produced over 10,000 tons was in sheets of 16 gage and lighter that went into the highest grade of automobile body and crown fender stock.

The Butler 42-inch Mill

In 1924 5 plans were laid for the commercial production of broad strips in widths up to 36 inches and 18 gage and heavier.

The steel plant at Butler, Pa., known as the Forged Steel Wheel Company, was consolidated with the allied interest, the Columbia Steel Company, of Elyria, Ohio, the consolidation taking the name of the latter company. On August 1, 1927, the ownership of the combined companies passed into the hands of the American Rolling Mill Company.

The construction of the mill was commenced early in 1926, the buildings housing an 18-inch and an 18-inch-12-inch 9-inch merchant mill being utilized to house the new mill. Two producer gas fired, continuous heating furnaces, 14 feet wide inside by 55 feet long, belonging to the 18-inch merchant mill were utilized to heat the slabs for the new mill. Slabs were produced on the universal slabbing mill belonging to the steel plant of the Forged Steel Wheel Company, and ranged in size from 12 inches to 36 inches in width, by $2\frac{1}{2}$ inches to 5 inches in thickness, and from 6 feet to 12 feet 6 inches in length.

The slabbing mill consists of a two-high, reversing, universal roughing stand with vertical rolls on both sides. The horizontal rolls are 27 inches by 48 inches and the

vertical rolls are so arranged as to go back into the housings and give a maximum opening of 37 inches thus utilizing nearly the full length of the body of the horizontal rolls.

The finishing mill, located 165 feet away from the universal mill, consists of four stands of 16½-inch and 40-inch by 42-inch four-high rolls, equipped with roller bearings, and spaced on 22-foot centers, with loopers between.

The universal roughing stand is driven by a 5000 H.P., reversing, D.C. motor, having a speed range from 0 to 150 R.P.M., directly connected to the mill. The four finishing mills are each driven by a 2000 H.P., adjustable speed, D.C. motor connected to the mill through gear reduction. Total H.P., 13,000.

PASS TABLE

Pass No.	Type	Rolls Diameter	Rolls Length	R.P.M.	Distance to next pass	Motor H.P.	Motor R.P.M.
1	universal						
2	universal						
3	universal	27"	48"	0 to 150	165' 0"	5000	0 to 150
4	universal						
5*	universal						
6	flat	16½" 32"	42"	55.4 to 110.8	22' 0"	2000	200 to 400
7	flat	16½" 32"	42"	76.7 to 153.4	22' 0"	2000	200 to 400
8	flat	16½" 32"	42"	98.4 to 192.8	22' 0"	2000	200 to 400
9	flat	16½" 32"	42"	107.4 to 214.8		2000	200 to 400

* The slab is given a varying number of passes in the roughing stand.

The heated slab, after leaving the furnace, passes through a scale breaker consisting of five staggered corrugated rolls which serves to break up the furnace scale. It passes to a manipulator which turns it over and knocks off the loosened scale, and then passes to the mill.

The slab receives from 5 to 7 passes in the universal stand where it is reduced to a thickness of from ¼ inch up to ½ inch, according to the required thickness of the finished strip. On leaving the universal mill it passes direct to the finishing mill, receiving one pass in each stand.

From the last stand of the finishing mill, the piece travels down a roller table to a coiler where it is coiled up for further operation. Heavy gage material may also be cut to length

by a shear in the line of the roller table without passing through the coiler.

This mill represented the first application of the four-high mill to the hot rolling of strip, and this, together with the high finishing speed, was the means relied upon to secure the thin gage and wide width desired.

The mill started operation in November, 1926 and has produced strips from 12 inches to 36 inches in width and from 3/16 inch down to .058 inch in gage. The mill has rolled as much as 1000 tons in 24 hours and in March, 1927 produced over 14,000 tons, and in June, 1927 over 16,000 tons of hot rolled material.

The hot strip sheet mill was designed to produce gages as light as No. 16 only. When lighter gages are required they are produced by cold rolling.

For this purpose there are six four-high cold mills located in a parallel bay of the building, the intermediate bay being occupied by the continuous pickling and annealing equipment. The coils of hot finished material are transferred to this latter bay where they are passed through a continuous pickler, being uncoiled just before entering the pickling bath, the front end of each coil being welded to the back end of the preceding coil in such manner as to make the process continuous. After pickling, the strip is coiled up again and the coils divided by shearing out the welded portion. The pickled coils are then transferred to the cold mill building where they receive the required number of passes to reduce them to the gage desired. The coils are then transferred back to the central bay where they are annealed in a continuous furnace to remove the effects of the cold rolling. After annealing it may or may not receive a further reduction as determined by the physical properties desired.

The Development of the Four-High Mill

At this time, a word or two regarding the development of the four-high mill will not be out of place. The earliest application of the backing-roll principle, as applied to the rolling mill, of which we have any record, is in 1864 when

Note

Text ends at this point,
without explanation or notice.

Office - Supreme Court, U.S.
FILED
DEC 13 1957
JOHN T. FEY, Clerk

IN THE

Supreme Court of the United States

NO. 680

OCTOBER TERM, 1957

THE COLD METAL PRODUCTS COMPANY,
Petitioner,

v.

CRUCIBLE STEEL COMPANY OF AMERICA,
Respondent.

PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE THIRD CIRCUIT

WILLIAM H. WEBB
1220 Farmers Bank Building
Pittsburgh 22, Pennsylvania
Counsel for Petitioner

MORTON BURDEN, JR.
1220 Farmers Bank Building
Pittsburgh 22, Pennsylvania
Of Counsel

SMITH BROS. CO., INC., LAW PRINTERS, 434-436 BLVD. OF ALLIES, PITTSBURGH 19, PA.

INDEX

	PAGE
The Opinions Below	1
Jurisdiction	2
Questions Presented	2
Rule Involved	3
Statement	4
A. The Nature of the Case	4
B. The Subject-Matter of the Patents	6
C. As to Questions I and II	12
The '107 Patent	12
The '122 Patent	14
D. As to Question III	18
Reasons for Granting the Writ	19
Conclusion	21
Appendix	
Opinion of the Court of Appeals	1a
Judgment of the Court of Appeals	19a
Rule 52(a) of the Federal Rules of Civil Procedure	20a

TABLE OF CASES

Carnegie Steel Company v. Cambria Iron Company, (1902) 185 U.S. 403	3, 18
Graver Tank & Mfg. Co., Inc. et al. v. Linde Air Products Co., (1949) 336 U.S. 271; (1950) 339 U.S. 605	3, 13, 16, 19, 20
Great Atlantic & Pacific Tea Co. v. Supermarket Equipment Corp., (1950) 340 U.S. 147	19
Minerals Separation, Limited, et al. v. Hyde, (1916) 242 U.S. 261	3, 18
O'Brien v. O'Brien, (7 Cir., 1953) 202 F. 2d 254	19
Seabury v. Am Ende, (1894) 152 U.S. 561	18
The Telephone Cases, (1888) 126 U.S. 1	18
The University of Illinois Foundation v. Block Drug Co., Amm-i-dent, Inc. and F. W. Woolworth Co., (7 Cir., 1957) 241 F. 2d 6	19

IN THE

Supreme Court of the United States

NO. ....

OCTOBER TERM, 1957

THE COLD METAL PRODUCTS COMPANY,
Petitioner,

v.

CRUCIBLE STEEL COMPANY OF AMERICA,
Respondent.

PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE THIRD CIRCUIT

To the Honorable Chief Justice and the Associate Justices of the Supreme Court of the United States:

Petitioner prays that a writ of certiorari issue to review the judgment of the United States Court of Appeals for the Third Circuit, entered in the above entitled action on August 9, 1957 (rehearing denied September 25, 1957).

THE OPINIONS BELOW.

The opinion of the District Court is reported at 147 F. Supp. 25 and is printed in Cold Metal's appendix filed in the Court of Appeals (P. App. 229a-246a), nine copies

of which have been filed herein.* The opinion of the Court of Appeals is reported at 247 F. 2d 241 and is printed in the appendix hereto, *infra,* pages 1a to 18a. The petition for rehearing filed by Cold Metal was denied without opinion.

JURISDICTION.

The judgment of the Court of Appeals (App., *infra,* p. 19a) was entered on August 9, 1957 and a petition for rehearing was denied on September 25, 1957. The jurisdiction of this Court is invoked under 28 U.S.C., Section 1254(1).

QUESTIONS PRESENTED.

I.

Did the Court of Appeals (a) in rejecting and reversing express findings of the District Court on controlling factual matters, which are fully supported by substantial evidence, namely, the testimony of witnesses for both parties, and (b) in rejecting a positive admission of respondent, violate and fail to conform to Rule 52(a) of the Federal Rules of Civil Procedure, which states:

---

* Petitioner, The Cold Metal Products Company, will be referred to herein as "Cold Metal" and respondent, Crucible Steel Company of America, as "Crucible."

Cold Metal's Appendix filed in the Court of Appeals will be referred to as P. App. ——.

Cold Metal's Supplemental Appendix filed in the Court of Appeals will be referred to as P. Supp. App. ——.

Crucible's Appendix filed in the Court of Appeals will be referred to as R. App. ——.

Nine copies of each have been filed herein.

"Findings of fact shall not be set aside unless clearly erroneous, and due regard shall be given to the opportunity of the trial court to judge of the credibility of the witnesses."

II.

Is the decision of the Court of Appeals, in which it determined controlling factual matters contrary to the express findings of the District Court and all the pertinent evidence and admissions, in conflict with the decisions of this Court in *Graver Tank & Mfg. Co., Inc. et al. v. Linde Air Products Co.,* (1949) 336 U.S. 271, 274-275, and 339 U.S. 605, 609-10?

III.

Is the decision of the Court of Appeals construing the disclosure of a patent contrary to the testimony of the witnesses for both parties as to the meaning of that disclosure to those skilled in the art in conflict with this Court's decisions in *Carnegie Steel Company v. Cambria Iron Company,* (1902) 185 U.S. 403, 437; *Minerals Separation, Limited, et al. v. Hyde,* (1916) 242 U.S. 261, 270-71, and others, holding that a patent disclosure is addressed to those skilled in the art?

RULE INVOLVED.

Rule 52(a) of the Federal Rules of Civil Procedure is involved. It is printed in the appendix hereto, *infra*, p. 20a.

STATEMENT.

A. The Nature of the Case.

On September 30, 1946, Cold Metal granted to Crucible a license (P. App. 80a) under several patents directed to reversing hot strip mills for the production of hot rolled steel strip. In 1948 and early 1949, Crucible, under its license, installed a reversing hot strip mill and placed it in commercial operation about April 1, 1949. Crucible paid royalties (but not all which were due) under its license agreement from April 1, 1949 to November 30, 1951.

In October and November of 1951, after the three earliest patents included in the license had expired, Crucible made certain modifications in its mill which it contended took the mill outside the scope of the licensed patents remaining in force. Cold Metal inspected Crucible's modified mill, found it still within three of the licensed patents, and brought suit for royalties due under the contract for operation of that modified mill and also for additional royalties due on the original mill.

On April 1, 1953, while the litigation on the contract was pending, Crucible canceled the agreement pursuant to its terms and later filed a supplemental counterclaim seeking a declaratory judgment that the three patents which Cold Metal had charged were being infringed were invalid and not infringed by Crucible in its operation of the mill from and after April 1, 1953.

The case before the District Court and the Court below thus presented the following issues:

(a) Whether the modified Crucible mill and its operation, during the period from November 30,

1951 to April 1, 1953, came within the scope of any claim of three of the licensed patents, *viz.* 2,214,107, 2,072,122 and 2,087,065.*

(b) Whether the three patents were valid and infringed by the modified mill and its operation after April 1, 1953.

The District Court, on the basis of substantial evidence, held that, during the existence of the license, the Crucible modified mill came within the scope of each of the three licensed patents. As to operations after cancellation of the license agreement, the District Court held patents '065 and '107 invalid and, therefore, not infringed; but it held certain claims of the '122 patent both valid and infringed. It also gave judgment for the additional royalties due under the license agreement for the operation of the original mill.

The Court below, despite substantial evidence supporting the District Court's findings, held that Crucible's operation of its modified mill, during the period from November 30, 1951 to April 1, 1953 (while the license was still in force), was not within the scope of any of the three patents, and further held that, as to the period subsequent to April 1, 1953, the three patents were invalid and not infringed.

This petition for *certiorari* challenges the holdings of the Court below that the Montgomery '107 and '122 patents did not cover the operation of the modified Crucible mill while the license agreement was in force and also the decision of the Court below holding invalid

---

* These patents are referred to hereinafter by the last three digits, *e.g.* '107, '122 and '065.

and not infringed Claims 6, 18 and 19 of the Montgomery '122 patent. It is these holdings which are squarely in conflict with Rule 52(a) and applicable decisions of this Court.

B. The Subject-Matter of the Patents.

The patents under which the license was granted relate to a reversing hot strip mill used for the hot rolling of relatively thick ingots and slabs into relatively thin gauge steel strip in long lengths. A typical steel ingot is fifteen inches high, twenty or twenty-two inches wide, fifty-four inches long, and weighs up to 24,000 pounds. A typical product of the mill is hot steel strip .080 inch thick and eighteen to fifty inches wide.

Other mills are used to produce hot steel strip, notably multi-stand 4-high continuous mills. Such mills, however, are huge and tremendously expensive and, therefore, can be built and operated only by the few largest steel companies in the country, not only because of their high initial cost but also because of the problem of supplying such a mill with material to keep it running. The reversing hot mill was invented by Cold Metal's engineers to meet the requirements of small steel companies who could not afford a large continuous mill but who, nevertheless, needed a source of hot steel strip.

Crucible was and is such a small company. It did not have the capacity to supply a continuous mill and keep it going and it could not afford the cost of such a mill, which was in the order of 35 to 40 million dollars, whereas the reversing hot strip mill which it installed under license cost only 6½ million dollars (App. 59a-

62a). The mill thus enabled Crucible to manufacture its own hot strip rather than buy it from others or send its slabs out and have them rolled to hot strip by others. The mill has many substantial advantages over other mills and Crucible enjoyed those advantages (P. App. 62a).

The licensed patents have enjoyed considerable commercial success. A number of the mills have been built and a number of licenses have been granted, both in this country and abroad (P. App. 33a).

Cold Metal built the first reversing hot strip mill at the Brier Hill plant of the Youngstown Sheet & Tube Company as an experiment to determine the feasibility of rolling hot steel strip on a reversing mill. That mill served to demonstrate the requirements for and the commercial practicability of this new mill.

That experimental mill is shown in Steckel patent No. 1,977,214 (P. App. 197a). Referring to Figures 2 and 3 of the patent, it will be seen that the mill comprises a roll table on each side of a reversing mill having working rolls 54 between which the steel passes and is reduced. The material is rolled back and forth through the mill on the roll tables until it is thin enough to coil, whereupon, as the material comes from one side of the mill or the other, a "kick-up" 90 is raised so as to deflect the material onto a coiler 69 (see Figures 3 and 4). The coiler is driven so as to wind up the strip. At this time also, pinch rolls 68, which have been raised from the table to permit passage of the thick material, are lowered onto the strip to feed the strip to the coiler.

After all of the material has passed through the mill and before the trailing end goes through the pinch rolls 68, the coiler, the pinch rolls, and the mill are reversed. The pinch rolls 68 feed the strip back through the rolls of the mill 54, through the pinch rolls 68 on the other side of the mill, and into a coiler 69, also on the other side of the mill. This process is repeated until the material reaches the desired thinness.

The pinch rolls 68 are raised from the roll tables to a "high lift" position while thick material is being rolled, but they are lowered onto the strip to a "pinch" position when it is coiled and, according to the teaching of the patent, they remain down on the strip throughout the rest of the operation.

While Steckel's experimental mill demonstrated the feasibility of a reversing hot strip mill, many difficulties were encountered in its operation. It was difficult to cause the hot, flabby material being rolled to enter the rolls properly and, unless the material, particularly in the later stages of rolling, was entered with great care, cambered strip (strip longitudinally curved) resulted. There was trouble with the pinch rolls, which slit the strip instead of feeding it into the mill and which damaged the roll bearings in dropping from the high-lift position to the pinch position (P. App. 37a, 46a-47a). There was trouble in synchronizing the various operating parts of the mill (P. App. 36a) and considerable trouble in handling the hot, flabby strip. There were days in the four years of experiments when no slabs could be rolled successfully and they were indeed fortunate if, out of six or eight slabs, they successfully rolled one down to .100" (P. App. 36a).

The two patents with which this petition is concerned are directed to improvements which Mr. Montgomery invented during the long experimental period to solve the difficulties just listed.

Referring first to the '107 patent (P. App. 113a) and the one claim of that patent here involved (Claim 6), it is directed to a method of operation which eliminated the problem of camber or longitudinal curvature in the strip. The particular operation claimed is one in which the strip is passed back and forth between the reducing rolls, coiled on one side and uncoiled on the other and includes the steps of passing an end of the breakdown or strip entirely through the rolls, frictionally gripping the end of the strip to feed it back through the rolls and freeing the portion of the strip between the mill and the points of coiling so as to avoid any pinching action between these points, and, finally, *uniformly* tensioning the portion of the strip between the mill and the points of coiling.

The claims of the Montgomery '122 patent here involved are directed to a reversing hot mill with pinch rolls on at least one side of the mill and mechanism for operating the pinch rolls whereby they can be shifted into three separate positions, *i.e.*, a pinch position, a low-lift position, and a high-lift position. The pinch rolls in Steckel's experimental mill had only two positions, a pinch position and a high-lift position.

The additional low-lift position, conceived by Montgomery, gave the pinch rolls entirely new functions and the claims here involved are directed to mechanism which Montgomery developed whereby the pinch rolls could

be moved so as to carry out these new functions. Thus, during the rolling, the pinch rolls, according to Montgomery, are raised from the pinch position to a low-lift position so as to free the strip and so that the coilers and uncoilers can be used to provide uniform tension on the strip (P. App. 41a-42a; 56a; P. Supp. App. 15a-16a). At the end of each pass, the pinch rolls are lowered from the low-lift position to the pinch position to act as a brake on the strip and prevent the trailing end of the strip from going into the coiler furnace (R. 493-94); and, at the beginning of each pass, they are used for feeding.

Originally the "low-lift" position was designed to prevent damage to the strip and to the pinch rolls when the pinch rolls were dropped onto the strip from the high-lift position, but it was found "to our great surprise" (App. 77a-78a) that, when in the low-lift position, the pinch rolls performed several functions entirely new to pinch rolls as known in the art and new to pinch rolls as shown in the Steckel '214 and Keeney and Ferm patents. When in this position, the pinch rolls provide a vertical guiding action, holding the strip down inside side guides and thereby keep the strip under the control of the side guides, which, in turn, assist in preventing cambering (P. App. 52a-54a). The pinch rolls also minimize damage to the strip in the event that the strip strikes the side guides (R. App. 61b). They provide a lateral guiding action and limit sidewise movement of the strip (P. App. 40a-41a). They assist in maintaining uniformity of tension (P. App. 43a-44a, 54a-55a, 71a). They keep any looping of the strip away from the coilers (R. App. 21b-22b; P. App. 53a-55a). Thus, if a loop is formed on the strip on the exit side of the mill

because the mill is momentarily running faster than the winding coiler, the pinch roll in the low-lift position on the exit side of the mill keeps the loop between the mill and the pinch roll and prevents it from going over to the coiler where it would interfere with the reeling of the strip on the coiler (R. App. 21b-22b; P. Supp. App. 66a-67a). Finally, the pinch rolls in the low-lift position allow the strip to be raised from the table rolls and still be kept down within the side guides (P. App. 54a-55a).

The construction of the original Crucible mill is most readily seen in Exhibit P-16-3 (P. App. 135a) and the operation of the pinch rolls on the original mill is shown in Exhibit P-16-7 (P. App. 143a) in which the three different positions of the pinch rolls are illustrated.

In October and November of 1951, Crucible made two minor modifications in the mill which it contends took the mill outside the scope of the license agreement and avoided infringement after the agreement was canceled. The changes are best shown in Exhibit P-16-8 (P. App. 145a). Crucible's first modification was to change the drive for the "deflector roll" which is just below and slightly to the left of the coiler furnace wall. Originally, this deflector roll which guides the strip from the coiler down to the pinch rolls was driven continuously by a motor. Crucible's modification consisted in disconnecting this motor drive whenever the strip engaged the deflector roll so that it was then driven only by engagement with the moving strip.

The second change consisted in taking from the pinch roll assembly the intermediate or "low-lift position" and adding to the assembly an "auxiliary roll" which was brought down against the strip at the same

time that the old pinch roll assembly was put into the low-lift position. The action of the auxiliary roll is shown in Exhibit P-16-10 (P. App. 149a), in which the two positions of the auxiliary roll are illustrated, *i.e.*, a "low-lift position" when it engages the strip during coiling rolling and a "high-lift position" when it does not engage the strip.

The modifications just discussed had no effect whatever on the operation of the mill. The striking similarity between the modified Crucible mill and the mill shown in the two Montgomery patents is shown in the chart opposite this page, which is based on the testimony of Crucible's expert witness (P. Supp. App. 36a-47a, 53a-57a).

C. As to Questions I and II.

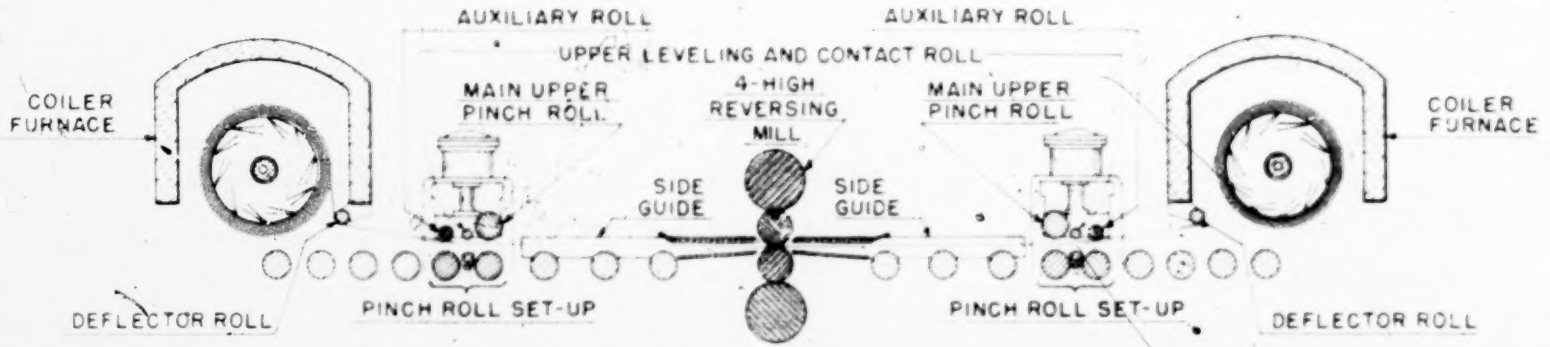
THE '107 PATENT.

The one claim in issue (Claim 6) of the '107 patent is directed to the operation of a reversing hot mill in which the portions of the strip between the reducing rolls in the mill and the coilers are freed and uniformly tensioned. The purpose of this operation is to avoid camber or sidewise curvature in the strip. Crucible contended that in its modified mill the strip was not freed between the mill and the coilers because the strip contacted two undriven rolls, the deflector roll at the mouth of the coiler furnace and the auxiliary roll which Crucible installed to take the place of the pinch rolls used on the original mill when in the low-lift position.

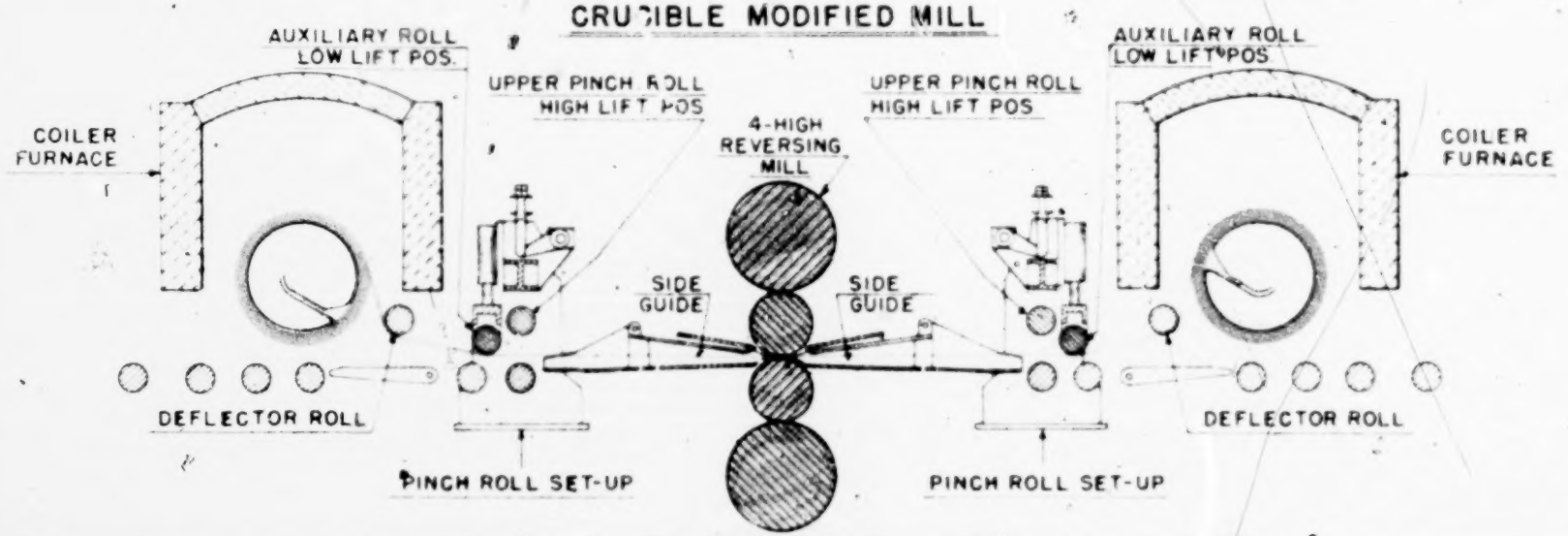
The District Court held (P. App. 240a-241a) that the contact of the strip with these undriven rolls had no effect on the operation of the mill and that, in Crucible's modified mill, the strip was freed and was

COMPARISON OF CRUCIBLE'S MODIFIED MILL AND THE MILLS OF MONTGOMERY '122 & '107

MONTGOMERY MILLS '122 & '107

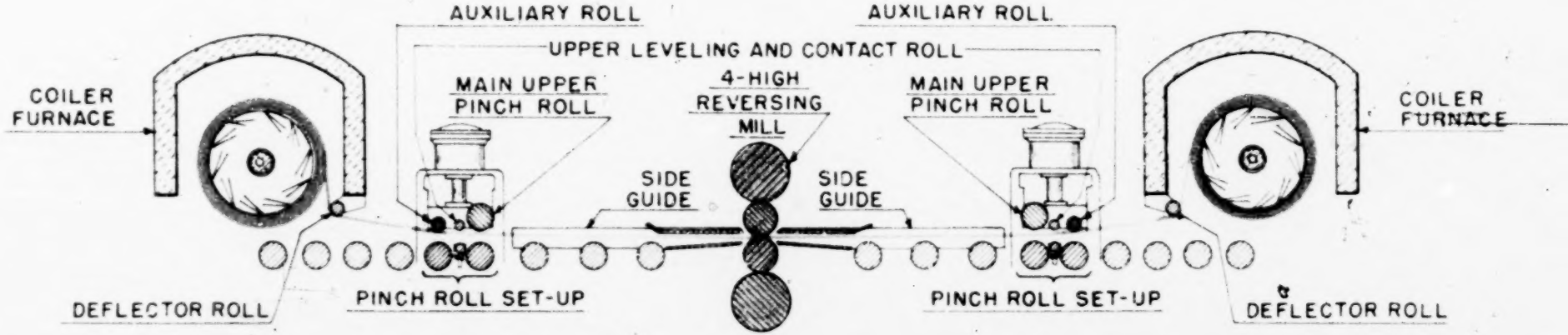


CRUCIBLE MODIFIED MILL

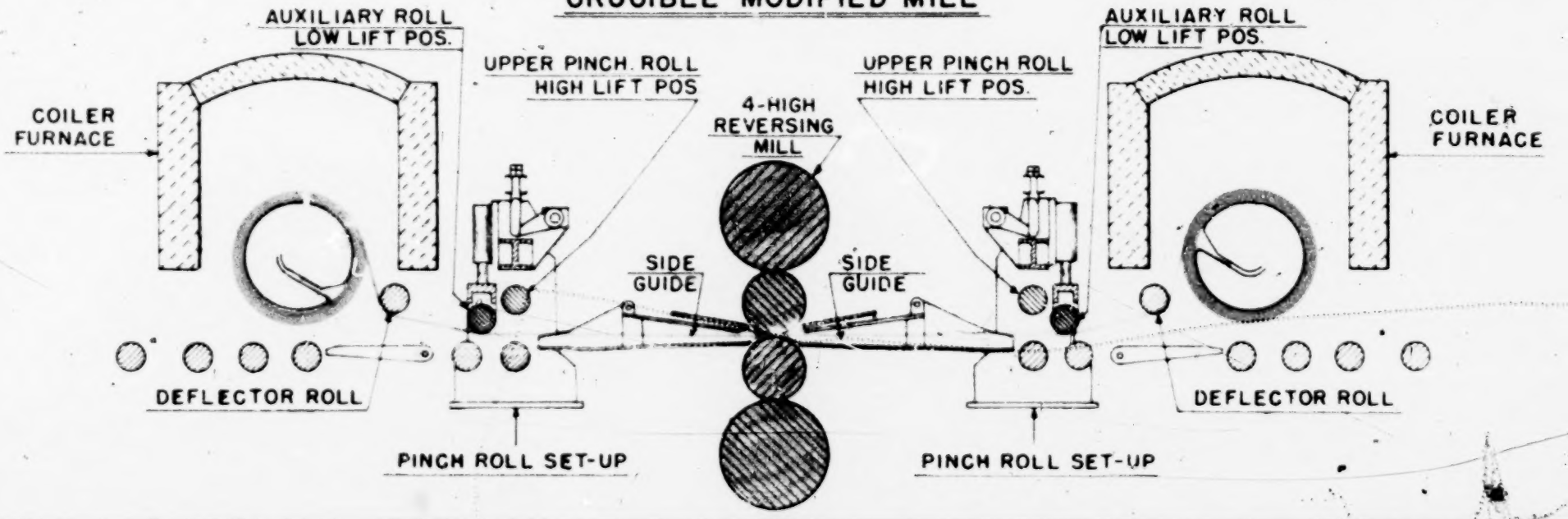


COMPARISON OF CRUCIBLE'S MODIFIED MILL AND THE MILLS OF MONTGOMERY '122 & '107

MONTGOMERY MILLS '122 & '107

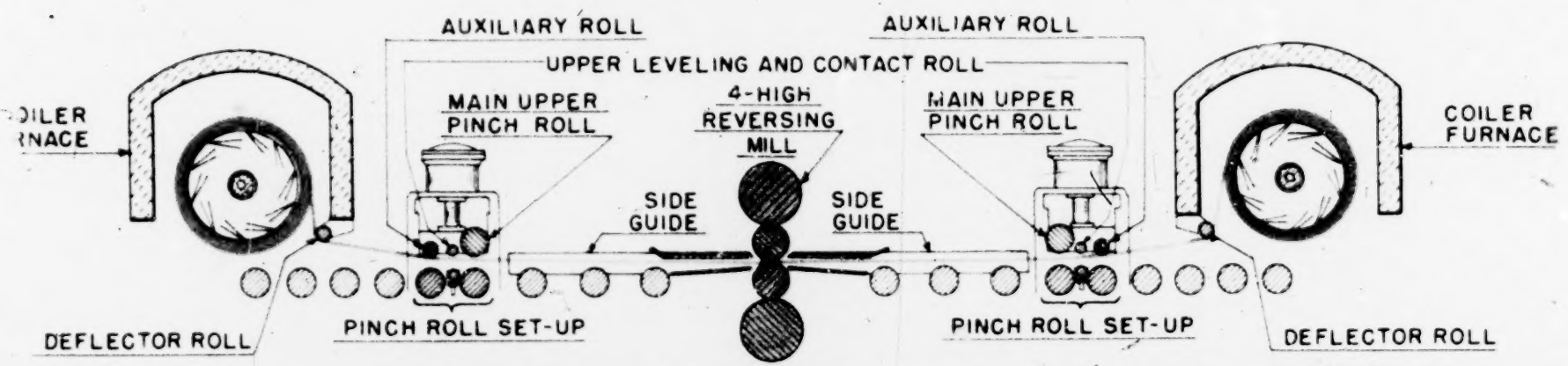


CRUCIBLE MODIFIED MILL

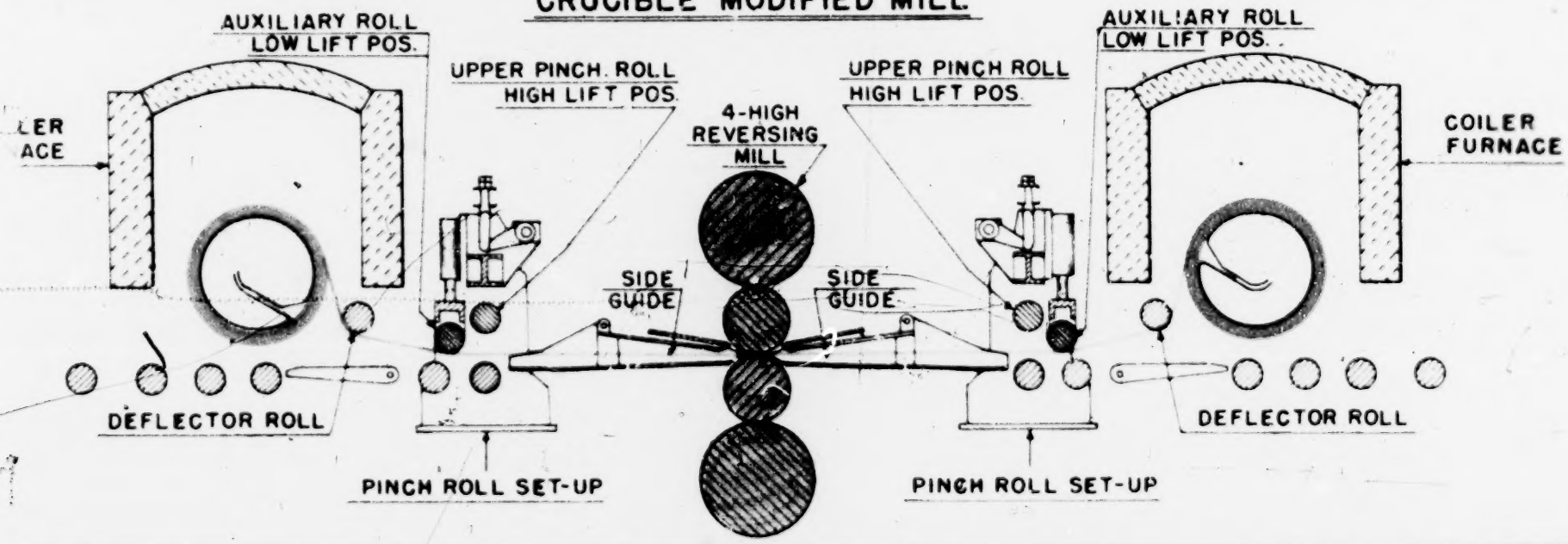


COMPARISON OF CRUCIBLE'S MODIFIED MILL AND THE MILLS OF MONTGOMERY '122 & '107

MONTGOMERY MILLS '122 & '107



CRUCIBLE MODIFIED MILL



uniformly tensioned, as required by Claim 6. In so holding, the District Court relied on the testimony of expert witnesses for both parties. For Cold Metal, the witnesses were Freed (P. Supp. App. 15a-16a; P. App. 49a-51a) and Sachs (P. Supp. App. 23a-24a; P. App. 56a, 72a). Crucible's expert testified to the same effect (P. Supp. App. 53a-54a, 57a-59a).

Crucible, in its brief entitled "Brief for Defendant as Appellant and Appellee" stated that (p. 61):

> "* * * as a practical matter the tension in the Crucible strip was substantially uniform notwithstanding its contact with two undriven rolls on each side of the mill."

Nevertheless, the Court of Appeals held that Claim 6 did not cover the modified mill, saying (App., *infra*, p. 18a):

> "* * * the strip in the Crucible mill is not uniformly tensioned between the mill rolls and the coiler as claim 6 teaches."

All the testimony in this case was given by expert witnesses for both parties. Rule 52(a) of the Federal Rules of Civil Procedure, which provides:

> "Findings of fact shall not be set aside unless clearly erroneous, and due regard shall be given to the opportunity of the trial court to judge of the credibility of the witnesses."

is, therefore, particularly applicable, as this Court has held: *Graver Tank & Mfg. Co., Inc. et al. v. Linde Air Products Co.*, (1949) 336 U. S. 271, 274-75; 339 U.S. 605, 609-10.

It is apparent from the decision of the Court below that it completely disregarded Rule 52(a) and the hold-

ing of this Court in the case just cited. It did not review the record to determine whether the holding of the District Court was "clearly erroneous" or whether the findings of the District Court were supported by substantial evidence. It simply proceeded to decide the case *de novo* and contrary to the evidence. There is substantial evidence to support the District Court's finding. Indeed, the finding of the Court of Appeals is *contrary to the entire record*. Clearly, the Court below did not follow Rule 52(a), as interpreted by this Court, and its decision on this point should be set aside.*

THE '122 PATENT.

As explained (*supra*, pp. 9-11), the claims of the '122 patent relate to the mechanism for operating the pinch rolls and are based on Montgomery's concept of providing the pinch rolls with an intermediate or "low-lift" position which is maintained while the strip is being rolled and coiled. New functions and advantages flowing from this arrangement of the pinch rolls were expressly found by the District Court (P. App. 244a-245a) and, therefore, it held the claims valid (P. App. 244a).

The District Court also held that Claims 6, 18 and 19 covered Crucible's modified mill, saying that the elimination of the low-lift position from the pinch rolls and the addition of an auxiliary roll to carry out the function formerly performed by the pinch rolls in the low-lift position "made no operational difference" and that the mill infringed after the cancellation of the license (P. App. 240a).

---

* This issue—whether Claim 6 covers Crucible's modified operations—is of great importance, irrespective of validity, because of the contract issues involved.

The Court of Appeals rejected the District Court's findings of new functions and advantages arising out of the new low-lift position which Montgomery gave to the pinch rolls (P. App. 244a-245a), despite the fact that those findings are based squarely upon undisputed testimony of experts (P. App. 40a-44a, 53a-56a, 71a; P. Supp. App. 15a-16a, 66a-67a; R. App. 21b-22b, 61b.) The Court of Appeals also rejected the findings of the District Court, based squarely upon the testimony of the experts for both parties (*infra*, p. 16), as to Montgomery's teachings as to the operation of the mill described in the '122 patent. The Court below, in complete disregard of *all the evidence* and the District Court's findings, proceeded to chart a novel, erroneous course on which it based its conclusions that the '122 patent did not cover the modified licensed mill, that the patent was invalid and that it was not infringed in the post license period. It based those holdings on its novel view that the new functions of the pinch rolls when in low-lift position were not performed by the Montgomery pinch roll assembly and were contrary to Montgomery's teaching (App., *infra*, 9a-10a).

The Court below relied on a few phrases taken out of context from the Montgomery specification. The difference between the holdings of the District Court and the Court below lies entirely in the fact that the District Court followed the testimony of expert witnesses *for both parties*, whereas the Court below completely ignored the District Court's findings and the testimony. The issue was whether the Montgomery patent taught that the pinch rolls engaged the strip and held it down within side guides when the pinch rolls

were in a low-lift position. Cold Metal's expert testified that the patent did teach an arrangement in which the pinch rolls, when in a low-lift position, did hold down the strip (P. App. 50a-51a) and Crucible's expert witness likewise so testified (P. Supp. App. 44a-47a, 51a-52a; P. App. 40a-42a; R. App. 70b-71b). This is the arrangement shown in the chart appearing opposite page 12. The showing of the chart was completely rejected by the Court below although based squarely on the testimony of *Crucible's* expert.

The Court below completely ignored the testimony just mentioned and the findings of the District Court in complete violation of Rule 52(a). The Court below also ignored the fundamental rule of patent law, as enounced by this Court, that a patent is directed to those skilled in the art. This point is discussed under Question III.

The fundamentally erroneous view of the Court below, in regard to its function, is apparent from the face of its opinion. It said (App., *infra*, 6a):

> "The first question for our consideration on these appeals is whether the district court erred in holding the claims in suit of Patent No. 2,072,122 valid and infringed * * *."

The question before the Court below was not whether the District Court "erred", but whether the District Court's holdings were, as stated by this Court in *Graver Tank & Mfg. Co., Inc., et al. v. Linde Air Products Co.*, (1949) 336 U. S. 271, 274-75, "clearly erroneous" and not "supported by substantial evidence." The Court below, as appears from its opinion, did not pass on these questions. It did not even function as a

trial court for it ignored the evidence given by experts for both parties. Apparently, it is of the opinion that neither Rule 52(a) nor the fundamental rule that a decision should be based on the evidence applies to suits involving questions of the validity and infringement of patents. It should be set straight on such erroneous beliefs.

The action of the Court below, in deciding this case contrary to *all* the evidence and the findings by the District Court, is such a departure from the accepted and usual course of judicial proceedings as to call for the exercise of this Court's power of supervision. This is not a case of weighing conflicting testimony. It is a case of *ignoring* all the testimony and an express admission of one of the parties. Nor is there any question as to the application of the proper standard of invention. There are only plain questions of fact as to the operation of a rolling mill and the disclosure of a patent. On these questions, the Court below substituted its own judgment for the undisputed testimony of workers skilled in the rolling art. Such action calls for an exercise of this Court's power of supervision.

D. As to Question III.

As explained, *supra*, page 15, the Court below, in holding Claims 6, 18, and 19 of the '122 patent invalid and not infringed, substituted its own construction of the disclosure of the patent for the unanimous opinion of the experts for both parties as to what the patent taught them, the question being whether Montgomery, in this patent, taught that the pinch roll assembly, when in the low-lift position, remained in contact with the strip. In so doing, the Court below decided this case contrary to applicable decisions of this Court, all of which hold that the disclosure of a patent is directed to those skilled in the art to which the patent pertains. See:

The Telephone Cases, (1888) 126 U. S. 1, 536;
Seabury v. Am Ende, (1894) 152 U. S. 561, 567;
Carnegie Steel Company v. Cambria Iron Company, (1902) 185 U. S. 403, 437; and
Minerals Separation, Limited, et al. v. Hyde, (1916) 242 U. S. 261, 270-71.

The *Carnegie Steel* case, *supra*, is peculiarly applicable to the case at bar. In sustaining a patent to a method of mixing molten pig metal, this Court stated (p. 437):

> "The specification of the patent is not addressed to lawyers, or even to the public generally, but to the manufacturers of steel. * * *"

In the present case, we are concerned with the hot rolling of steel and we have the unanimous testimony of experts in the rolling art as to the teaching of the Montgomery patent. In refusing to follow the testimony of the experts, the Court below acted contrary to all of the applicable decisions of this Court.

REASONS FOR GRANTING THE WRIT.

1. The question whether Rule 52(a) of the Federal Rules of Civil Procedure is applicable to appeals in patent cases and, if so, the extent to which it applies should be finally decided by this Court. After this Court's decision in *Graver Tank & Mfg. Co., Inc. et al. v. Linde Air Products Co.*, (1949) 336 U. S. 271, it seemed clear that the rule did apply to appeals in patent cases. However, this Court's decision in *Great Atlantic & Pacific Tea Co. v. Supermarket Equipment Corp.*, (1950) 340 U. S. 147, created doubt in the Courts of Appeals for the different circuits. For an expression of this doubt, see *O'Brien v. O'Brien*, (7 Cir., 1953) 202 F. 2d 254. While expressing doubt, the Court of Appeals concluded that Rule 52(a) was applicable to appeals in patent cases, saying (p. 256):

> "Whether this is any indication that the Supreme Court has or is about to retract or modify its emphatic pronouncement in the Graver case on the weight to be attached to the findings in a patent case, we do not know. However, until the Supreme Court has expressly done so we think this court should evaluate the findings in a patent case the same as in any other."

The Court of Appeals for the Seventh Circuit has adhered to this rule. See *The University of Illinois Foundation v. Block Drug Co. et al.*, (7 Cir., 1957) 241 F. 2d 6, wherein the Court stated (p. 10):

> "Thus, in reality the issues here are not merely those of invention and infringement but whether this Court can say that the findings of the District Court on these issues are clearly erroneous."

In contrast to this proper statement of the issues before a Court of Appeals in a patent case, the Court below stated (App., *infra*, p. 6a):

> "The first question for our consideration on these appeals is whether the district court erred in holding * * *."

From this statement, the only conclusion which can be drawn is that the Court below believed that the case was to be considered *de novo* by it and completely unrestrained by Rule 52(a) of the Federal Rules of Civil Procedure. There is thus a conflict in decision between Courts of Appeals on an important question of federal procedure, and this conflict should be settled by this Court.

2. The decision of the Court below on the issues discussed above is squarely in conflict with this Court's decision in the *Graver* case, *supra* pp. 13, 16, 19.

3. The action of the Court below in deciding this case contrary to all of the evidence is such a departure from the accepted course of judicial proceedings as to call for this Court's supervision.

4. The decision of the Court below is in conflict with prior decisions of this Court holding that the specification of a patent is directed to those skilled in the art.

CONCLUSION.

We respectfully submit that the decision of the Court below is clearly erroneous and that this petition should be granted.

Respectfully submitted,

WILLIAM H. WEBB
Counsel for Petitioner

MORTON BURDEN, JR.
Of Counsel

December 23, 1957

APPENDIX

OPINION OF THE COURT OF APPEALS

Decided Aug. 9, 1957.

Rehearing Denied Sept. 25, 1957.

Before MARIS, STALEY and HASTIE, Circuit Judges.

MARIS, Circuit Judge.

These are cross appeals by the plaintiff, Cold Metal Products Company and the defendant, Crucible Steel Company of America, from a judgment entered in the District Court for the District of New Jersey. They involve questions as to the validity of certain patents owned by Cold Metal, as to the infringement of the patents by Crucible after April 1, 1953, when a license agreement between the parties terminated, and as to Cold Metal's right to royalties from Crucible under the license agreement for the period November 20, 1951 to April 1, 1953. The patents in suit, Montgomery No. 2,072,122, Montgomery No. 2,087,065 and Montgomery No. 2,214,107, relate to improvements in apparatus and methods for rolling heated metal ingots into long thin strips in a reversing hot rolling mill.

One method of performing this operation is to use a continuous hot mill consisting of a roughing mill plus a finishing mill, the latter consisting of a number of mill stands set in a row, one after the other. In the operation of such a mill the original ingot is reduced in the roughing portion of the mill to the dimensions of a slab or "breakdown", which is then reduced to strip of the desired thickness by a single continuous pass through the row of mill stands comprising the finishing portion of the mill. The mill stands comprising the finishing por-

tion of such a mill have conventionally been 4-high mills equipped with antifriction bearings.

The other method of performing the operation is by the use of a reversing hot mill. The roughing portion of such a mill is not different from that of a continuous mill but the finishing operation, instead of being conducted by passing the material once through a succession of mill stands as in a continuous mill, is conducted by passing the strip back and forth through a single finishing mill stand, the rolls of which are brought closer and closer together for each successive pass until the strip has been reduced to the desired thickness. The mill stand used in such a reversing hot mill ordinarily is the same sort of 4-high mill with antifriction bearings as is used in the finishing portion of a continuous mill. On each side of the finishing mill stand are a roll table over which the strip passes, a pair of pinch rolls for gripping and moving the strip, side guides for confining it in its path, a deflector to direct it into the coiler furnace, and a coiler furnace and a coiling reel therein upon which the strip is wound as it is passed through the mill and kept heated for its next pass through the mill in the reverse direction. The Steckel Patent No. 1,857,670, the Keeney & Ferm Patent No. 1,918,968 and the Steckel Patent No. 1,977,214, all owned by Cold Metal and all now expired, cover basic features of reversing hot mills such as we have described. The three subsequently issued Montgomery patents in suit cover improvements in the apparatus and process of such mills.

Reversing hot mills do not produce as fine a product as is produced by continuous mills and their produc-

tivity necessarily is not as high but they do have the advantage of costing very much less than continuous mills. This advantage apparently appealed to Crucible and on September 30, 1946 it entered into a license agreement with Cold Metal covering Cold Metal's reversing hot mill patents, including, inter alia, the six patents above mentioned. Under this license agreement Crucible installed in its plant at Midland, Pennsylvania, a reversing hot rolling mill which it began to operate commercially on April 1, 1949. Its installation comprised a single stand universal roughing mill for rough rolling ingots into rectangular slabs and into relatively long and thin breakdowns and a single stand reversing hot finishing mill for hot rolling the breakdowns into continuous strip. Roll tables were installed in advance of the universal mill, between the universal mill and the reversing mill, and extended beyond the reversing mill for conveying ingots, slabs, breakdowns and strip into, through and out of the mill.

The license agreement called for the payment of royalties at a fixed rate during the lifetime of the three dominating Steckel and Keeney & Ferm patents, the last of which expired on October 16, 1951, and at half the original rate after that date, provided that Crucible's mill was thereafter covered by any claim of any of the remaining unexpired patents included in the license. Termination of the agreement was permitted on April 1, 1953 and it was terminated by Crucible on that date. Crucible paid Cold Metal royalties amounting to $655,189.54 until November 30, 1951, but none after that date, contending that its mill, as modified in October and November, 1951 was not covered by any claim of the licensed patents which still remained unexpired.

Cold Metal brought suit on December 18, 1952 in the District Court for the District of New Jersey for royalties allegedly due under the license agreement for the use of the mill and equipment for the period November 30, 1951 to April 1, 1953 and for royalties in addition to those already paid for the period April 1, 1949 to November 30, 1951. On July 2, 1954 it instituted an action in the District Court for the Western District of Pennsylvania against Crucible for infringement of the patents here in suit subsequent to April 1, 1953, the termination date of the license agreement. Crucible filed a motion in the District Court in New Jersey for leave to file a supplemental counterclaim seeking a declaratory judgment that Cold Metal's three Montgomery patents are invalid and noninfringed and asked the court to enjoin the prosecution of the Pennsylvania patent infringement suit. Cold Metal moved, pursuant to section 1404(a) of title 28 United States Code, for an order transferring the New Jersey action to the Western District of Pennsylvania. Crucible's motions were granted and Cold Metal's motion was denied. 126 F. Supp. 546.

In its supplemental counterclaim Crucible sought a declaratory judgment that the three Montgomery patents in suit are invalid and not infringed and also asked the court to enjoin any further suits under these patents. Cold Metal, in a counterclaim annexed to its reply to Crucible's supplemental counterclaim, charged infringement of its patents by the unauthorized use by Crucible of its mill after the termination of the license agreement, for which Cold Metal sought an accounting of profits and damages. In defense to this claim Crucible attacked the validity of the patents and asserted that the alterations in its mill and in the process employed

in its operation which it had made in October and November, 1951 and which were completed on November 19, 1951 had taken its mill out from under the claims of Cold Metal's unexpired patents.

Upon the trial of the present action in the District of New Jersey the district court found that Cold Metal was entitled to recover additional royalties under the license agreement for the period April 1, 1949 through November 19, 1951 and entered judgment in favor of Cold Metal in the amount of $146,210.38 together with interest amounting to $53,359.89, a total of $199,570.27. This amount was subsequently paid by Crucible and is not involved in the present appeals. The district court also found that the changes made by Crucible in its mill in October and November, 1951 did not relieve it from liability for royalties under the license agreement and that Cold Metal was entitled to royalties from November 20, 1951 to April 1, 1953, the termination date of the agreement, and entered judgment on this score in favor of Cold Metal in the amount of $334,942.97, together with interest of $88,259.24, a total of $423,201.31. Certain allowances were made to Crucible for royalty overpayments.

The district court held that claims 6, 10, 18 and 19 of Montgomery Patent No. 2,072,122 were valid and had been infringed by Crucible from April 1, 1953 to the date of the patent's expiration, March 2, 1954. The court accordingly adjudged Cold Metal to be entitled to recover damages for Crucible's infringement of that patent and referred to a master the determination of the amount of such damages. The court held that claims 1, 2, 3, 4 and 5 of Montgomery Patent No. 2,087,065 and

claims 4 and 6 of Montgomery Patent No. 2,214,107 were invalid. 147 F.Supp. 25. These cross appeals by Cold Metal and Crucible followed.

The first question for our consideration on these appeals is whether the district court erred in holding the claims in suit of Patent No. 2,072,122 valid and infringed and the claims in suit of Patents Nos. 2,087,065 and 2,214,107 invalid. In considering these questions we must bear in mind that these are not basic patents but merely claim improvements in the process and apparatus of the reversing hot rolling mill which was disclosed and the basic essentials of which were covered by the Steckel and Keeney & Ferm patents.[1] Those basic patents having expired, Crucible and all the world became free to use that mill. The three patents in suit must, therefore, disclose patentable improvements over Steckel and Keeney & Ferm in order to be valid. Moreover in order to justify a finding of infringement it must appear that these improvements on the prior art were employed in the Crucible mill after the changes therein were completed on November 19, 1951.

We consider first Montgomery Patent No. 2,072,122. Claims 6, 18 and 19 of this patent[2] relate to the

[1] Certain claims of the Keeney & Ferm Patent No. 1,918,968 and the Steckel Patent No. 1,977,214 have been held invalid in Cold Metal Products Co. v. Newport Steel Corp., 6 Cir., 1955, 226 F.2d 19.

[2] "6. In a rolling mill including a pair of housings and work rolls journaled therein, pinch rolls on one side of the mill, and means for raising one of the pinch rolls through a short distance, and independent means for raising the upper pinch rolls through a greater distance.

"18. In a rolling mill, a pair of housings having work rolls journaled therein, pinch rolls on at least one side of

pinch rolls employed in a reversing mill to engage the strip and feed it to the mill rolls or the coilers. Keeney & Ferm employed pinch rolls near the entrance to each of the coiling furnaces, which were held in engagement with the strip by adjustable springs and were provided with a motor drive to enable them to be used to feed strip toward the coiler or the mill rolls as the case might be. Their drives included magnetic clutches so that the drives would be disconnected and the rolls allowed to act as "idle guide rollers" when not required for feeding purposes. Steckel No. 1,977,214 had pinch rolls which, though originally intended to be used to apply tension to the strip as well as to feed it to the mill and coilers, were "arranged to be raised and lowered as desired". The raising and lowering was accomplished by controlling the supply of air to cylinders in which were located vertically moving pistons connected to the housing in which the pinch rolls were mounted. Since this was a single stand mill the upper limit of travel of the upper pinch roll had to be high enough to permit the passage of the thickest material to be passed through the mill.

It appears that when the raised pinch roll was dropped from such a height it came down with such

the mill for engaging material being worked in the mill, means for retracting one of said pinch rolls when unused for a substantial period, and independent means for temporarily retracting one of said rolls.

"19. The combination with a rolling mill and a roll table for advancing work thereto, of pinch rolls on one side of the mill, one of said pinch rolls being retractible, and means for retracting said roll including fluid pressure-operated cylinders and pistons, one of which has a short stroke for temporarily retracting the roll and the other having a longer stroke for retracting the roll when unused for substantial periods."

force as to involve danger of marring the strip and damaging the equipment. The evidence establishes that it was to remedy this situation that the improvement of the claims now under discussion of Patent No. 2,072,122 was directed. This was to add an extra pair of cylinders of shorter stroke so that the upper pinch rolls could be raised only a short distance off the strip by using these new cylinders or the original longer distance by using the original set of cylinders. The language of claims 18 and 19 suggests that the purpose is to use the low lift cylinders for temporarily retracting the upper pinch rolls and the high lift cylinders for retracting them for longer periods. We are satisfied that these claims disclose an obvious expedient, the addition to the means employed by Stegkel of another means of the same type to perform the same function of lifting the upper pinch rolls, but to a different and less elevated position. This was mere aggregation and in any event did not rise to the dignity of invention.

Cold Metal, however, argues and the district court held that the upper pinch rolls in the new low lift position perform new and useful functions not disclosed or claimed in the patent. It asserts that in this position they provide a vertical guiding action, holding the strip down inside the side guides and thereby keeping the strip under the control of the side guides and assisting in preventing cambering, they minimize damage to the strip in the event that it strikes the side guides, they provide a lateral guiding action and limit sidewise movement of the strip, they assist in maintaining uniformity of tension, they keep any looping of the strip away from the coilers, and finally they allow the strip to be raised from

the table rolls and still be kept down within the side guides.

The difficulty with this argument is that this use of the upper pinch rolls in the low lift position as guide and hold-down rolls is not taught by the patent but is in fact a departure from its teachings. For the specification of the patent refers to the pinch rolls when elevated to the low lift position as being "lifted off the strip", "lifted from the material" and "lifted out of the way when there is no further need for them." It is apparent that what Cold Metal is here asserting as covered by the claims of this patent is the procedure which Crucible employed in its licensed mill, not what the patent claimed. But the fact that Crucible prior to the changes completed on November 19, 1951 employed the upper pinch rolls in their low lift position for these purposes does not bring those functions within the scope of this patent. For as we have seen it was a departure from and not a use of the invention here claimed. Moreover the use of a roll as a guide in such a mill was fully disclosed in the prior art. Keeney & Ferm No. 1,918,968; Steckel No. 1,977,214. In any event at this stage of the art it was an obvious expedient to introduce such a roll where it was found to be needed. We conclude that the district court erred in holding claims 6, 18 and 19 of Patent No. 2,072,122 valid.

Little need be said with respect to the alleged infringement of these claims. Prior to November 20, 1951 Crucible admittedly used the double lift feature of the claims with respect to the pinch rolls of its mill. But by that date it had completed the removal of the additional short stroke cylinders from those rolls and had

installed wholly separate guide rolls on each side of the mill. These guide rolls undoubtedly performed the guiding functions which the upper pinch rolls in low lift position had theretofore performed in the Crucible mill. But, as we have seen, the performance of these functions by a guide roll such as Crucible installed was disclosed by the prior art while the performance of those functions by the pinch rolls was not taught by the patent, indeed was excluded by its teachings. And the apparatus actually disclosed in these claims of the patent, means for raising the pinch rolls through a short distance and independent means for raising them through a greater distance, was not used by Crucible after November 19, 1951. We conclude that the district court erred in holding that claims 6, 18 and 19 of Patent No. 2,072,122 were infringed by Crucible.

We turn then to the only other claim of Montgomery Patent No. 2,072,122 which is in suit, claim 10. This relates to the adjustable side guides on each side of the mill whose function is to guide the strip from the coiler to the mill rolls on the entering side of the mill and from the mill rolls to the coiler on the other side. Steckel No. 1,977,214 had taught that the guides should be positioned close to the sides of the strip on the entering side and should be farther apart on the other side. Their position was to be changed each time the direction of the strip through the mill was reversed. Montgomery taught that the guides should be adjusted on the delivery side of the mill so as not to be parallel but to form a tapered guiding throat and several of his claims are directed to this tapered feature. But since it was not followed by Crucible these claims are not here involved.

Claim 10 [3] is directed to the combination of a mill with a driving motor and a controller for the motor which also operates the means for shifting the adjustable side guides inwardly on the entrance side and outwardly on the exit side of the mill. The invention claimed is in the use of the single controller for the two purposes so that the position of the side guides will be automatically reversed when the direction of the mill is reversed. We cannot find invention in this combination. When it is desired to have two things happen simultaneously which are actuated electrically nothing is more obvious than to control them by the same switch. Claim 10 calls for no more than this. For Montgomery did not claim to invent the controller means or the idea that the guides should be adjusted each time the mill was reversed. The district court accordingly erred in holding claim 10 to be valid.

Nor do we think that the district court was right in holding that claim 10 was infringed. In the Crucible mill the teaching of claim 10 was originally followed. But in the summer of 1950 a new arrangement was made under which the side guides were caused to change their respective positions each time the mill motor circuit was opened to cause the mill to stop, the change in position being wholly independent of the direction in which the mill had been running or the direction in which it would next run. Whenever the mill stopped, whether

[3] "10. The combination with a rolling mill having a driving motor and a controller for the motor, of adjustable side guides on both sides of the mill, and means operated by said controller for shifting the guides inwardly on the entrance side of the mill and outwardly on the exit side of the mill."

by moving the motor controlier to the off position, by pushing the independent stop button with which the Crucible mill was also equipped or by the opening of the circuit breaker on overload, the side guides changed position. Thus it was the opening of the mill circuit from any cause, and not necessarily the movement of the motor controller, which caused the guides to change position. And even when the change of the side guides was actuated by the mill motor controller it was the action of the controller in stopping the mill which effected the change not its action in starting the mill in the opposite direction. We are satisfied that this changed procedure of the Crucible mill did not infringe claim 10 of Patent No. 2,072,122.

We consider next Montgomery Patent No. 2,087,065. This is a patent on a method of rolling metal strip in which the heated slab is first rolled sufficiently thin in a roughing mill for coiling and then in the same heat is fed to a reversing mill where it is subjected to successive passes to reduce it to the desired thinness, coiling it between passes in the reversing mill. All five claims of the patent are involved.[1] Claim 1 is the broad-

[1] "1. In a method of rolling metal strip, the steps consisting in supplying to a roughing mill a heated slab-like body which is too thick for coiling, rolling the body in the roughing mill until it is substantially thin enough to permit of coiling, but maintaining the thinned body in the flat state, and, in the same heat, feeding the thinned body to a reversing mill, subjecting it to successive passes therein to reduce it to a desired strip thickness, and coiling it between passes in the reversing mill.

"2. In a method of rolling metal strip, the steps consisting in supplying to a roughing mill a heated slab-like body which is too thick for coiling, rolling the body in the

est and the other four do not disclose any inventive differences over it. The district court did not err in

roughing mill until it is substantially thin enough to permit of coiling but maintaining the thinned body in the flat state, trueing the edges in said mill, and, in the same heat, feeding the thinned body to a reversing mill, subjecting it to successive passes therein to reduce it to a desired strip thickness, and coiling it between passes in the reversing mill.

"3. In a method of rolling metal strip, the steps consisting in supplying to a roughing mill a heated slab-like body which is too thick for coiling, rolling the body back and forth in the roughing mill until it is substantially thin enough to permit of coiling, but maintaining the thinned body in the flat state, and, in the same heat, feeding the thinned body to a reversing mill, subjecting it to successive passes therein to reduce it to a desired strip thickness, and coiling it between passes in the reversing mill.

"4. In a method of rolling metal strip, the steps consisting in supplying to a roughing mill a heated slab-like body which is too thick for coiling, rolling the body in the roughing mill until the body cools to a temperature below that at which free scale forms, and until it is substantially thin enough to permit of coiling, but maintaining the the thinned body in the flat state, and, in the same heat, feeding the thinned body to a reversing mill, subjecting it to successive passes therein to reduce it to a desired strip thickness, and coiling it between passes in the reversing mill.

"5. In a method of rolling metal strip, the steps consisting in supplying to a roughing mill a heated slab-like body which is too thick for coiling, rolling the body in the roughing mill until it is substantially thin enough to permit of coiling, but maintaining the thinned body in the flat state, and, in the same heat, feeding the thinned body to a reversing mill after cropping at least one end of the thinned body to facilitate its entry into said reversing mill, subjecting it to successive passes therein to reduce it to a desired strip thickness, and coiling it between passes in the reversing mill."

holding this patent invalid as being completely anticipated by the prior art.[5] The record established that it was usual to have a roughing mill operating in line with a continuous finishing mill and there is no difference in principle in using a roughing mill in conjunction with a reversing finishing mill as distinguished from a continuous finishing mill. Indeed that very combination is suggested in Keeney & Ferm and Steckel No. 1,977,214. And in the prior patent to Cushwa, No. 904,605, the conduct of such a continuous operation in the same heat is fully disclosed.

The last of the patents to be considered is Montgomery No. 2,214,107. Two claims of this patent are in issue, claims 4 and 6, which relate to methods of operating a reversing hot mill designed to permit the strip to be tensioned uniformly between the mill and the coiler. The district court held both claims to be invalid. Its holding of invalidity as to claim 4 is not seriously questioned in this court. We will, therefore, confine our consideration to claim 6 which describes the process, after the breakdown has passed through the rolls of a reversing mill, of feeding its end back into the mill

[5] This patent has been held invalid by the Court of Appeals for the Sixth Circuit in Cold Metal Products Co. v. Newport Steel Co., 1955, 226 F.2d 19.

"6. In a method of rolling strip, the steps, including passing a breakdown heated to plastic condition, back and forth between reducing rolls, uncoiling it on one side and coiling it on the opposite side of the rolls, passing an end of the breakdown entirely through the rolls, frictionally gripping said end to feed it back through the rolls, freeing that portion of the breakdown between the mill and the point of coiling, and tensioning such portion uniformly throughout."

rolls by frictionally gripping it with the pinch rolls and after it is engaged by the mill rolls freeing the part of the breakdown between the mill rolls and the point of coiling and tensioning that part uniformly throughout.

The district court was right in holding that claim 6 is invalid. Uniformly tensioning the strip between the mill rolls and the coiler is disclosed in Steckel No. 1,857,670. Tension on the strip is also employed in Keeney & Ferm and Steckel No. 1,977,214. In the latter two patents pinch rolls are interposed between the mill rolls and the coilers. In Keeney & Ferm these are so arranged as to maintain a continuous frictional grip upon the strip. But in Steckel provision is made for lifting the upper pinch rolls off the strip. Thus all of the steps of claim 6 are disclosed in the prior art. It was an obvious expedient to lift the gripping pinch roll off the strip after its engagement by the mill rolls in order to achieve the uniform tension in the strip which Steckel No. 1,977,214 had taught was needed to prevent cambering. To lift the retractible upper pinch rolls off the strip during times when their use was found to be unnecessary or detrimental to the operation was not invention.

It remains to consider Crucible's contention that the district court erred in holding that it was required to pay royalties under the license agreement for the period during which that agreement was in force after November 19, 1951. Such payment was required under the terms of the agreement if Crucible's mill or its operation was covered by one or more claims of the licensed patents. By November 19, 1951 the basic patents, Steckel No. 1,857,670, Keeney & Ferm No. 1,918,968

and Steckel No. 1,977,214 had all expired. But Cold Metal contends that the claims in suit of the three improvement patents involved in this case all covered Crucible's mill or its operation as it existed and was operated after the changes made on and prior to November 19, 1951. If any one or more of these does so Crucible concedes that it is required to pay royalty under the agreement. But it vigorously urges that none of the claims in suit covers its mills or operations. We turn then to consider this question.

So far as concerns the claims in suit of Montgomery Patent No. 2,072,122 our conclusion that these claims were not infringed because Crucible's mill and operations were not within their proper scope after the termination of the license agreement on April 1, 1953 is dispositive of the present question. For if the Crucible mill and operation did not infringe those claims the same mill and operation could not make Crucible liable to pay royalty under the license agreement by reason of the use of the patented invention. The issues in both situations are essentially the same. Hewitt v. American Telephone & Telegraph Co., D.C.N.Y. 1920, 272, F. 194, affirmed, 2 Cir., 1921, 272 F. 392; Cold Metal Process Co. v. United Engineering & Foundry Co., 3 Cir., 1956, 235 F.2d 224, 229.

Montgomery Patent No. 2,087,065 claims, as we have seen, a process involving a combination of a roughing mill and a reversing finishing mill in which the strip is passed from the roughing mill to the reversing mill in the same heat and then passed back and forth in the latter mill with coiling of the strip between the passes. Although the patent was invalid Crucible must pay

royalty under the agreement if its mill operation is covered by the claims of the patent. Nonetheless it is entitled to have the claims considered in the light of and their scope restricted by the prior art. Considered in that light the claims of this patent must be restricted for the present purpose to their exact disclosures. One of these is that the strip is coiled between every pass in the reversing mill. Indeed in this case Cold Metal is limited by file wrapper estoppel to that precise method in which the strip is coiled after every pass through the reversing mill and is never passed through that mill flat. Crucible, however, did not practice this precise process during the significant period. On the contrary it always passed the strip twice through the finishing mill flat before introducing it into one of the furnace coilers. Its operation was accordingly not covered by the claims of this patent.

Finally we consider claim 6 of Montgomery Patent No. 2,214,107,[7] which calls for a method of lifting the upper pinch rolls off the strip after it has been engaged by the mill rolls so as to provide uniform tension in the strip between the mill and the coiler. We are satisfied that Crucible did not in its mill operation follow the procedure of this claim but rather that of the prior art. For it interposed upon the strip the guide or hold-down roll which it installed when it removed from its mill the low lift pinch roll feature of Montgomery No. 2,072,122. And it also interposed upon the strip a guide roll at the furnace entrance. It was a part of the teaching of claim 4 of this patent, although not of claim 6, that a guide

[7] Cold Metal does not contend that Crucible's operation is covered by claim 4 of this patent.

roll should be driven "to prevent frictional drag on the breakdown." Since Crucible's rolls are undriven they necessarily exert some frictional drag upon the strip. As a consequence the strip in the Crucible mill is not uniformly tensioned between the mill rolls and the coiler as claim 6 teaches. It thus appears that Crucible did not practice the only novel feature of claim 6 of Patent No. 2,214,107.

To summarize our conclusions, the district court rightly held that the claims in issue of Montgomery Patents Nos. 2,087,065 and 2,214,107 are invalid, but the court erred in holding the claims in issue of Montgomery Patent No. 2,072,122 valid and infringed, in holding that the claims in issue of Patents Nos. 2,087,065 and 2,214,107 covered Crucible's modified mill and operations, and in awarding royalties for the period from November 20, 1951 to April 1, 1953, and damages for infringement of Patent No. 2,072,122 after that date.

Paragraphs 2, 5, 6, 7, 8, 9 and 10 of the judgment of the district court are involved in the appeals now before this court. Paragraphs 2, 5, 6 and 9 will be reversed, paragraph 10 will be vacated, paragraphs 7 and 8 will be affirmed and the cause will be remanded to the district court with directions to incorporate in the judgment a paragraph adjudging that claims 6, 10, 18, and 19 of U. S. Letters Patent No. 2,072,122 are invalid and an appropriate paragraph as to costs. Costs will be allowed to the defendant on each appeal.

JUDGMENT OF THE COURT OF APPEALS

ON APPEAL FROM THE UNITED STATES DISTRICT COURT FOR THE DISTRICT OF NEW JERSEY

Present: MARIS, STALEY and HASTIE, Circuit Judges.

JUDGMENT

This cause came on to be heard on the record from the United States District Court for the District of New Jersey and was argued by counsel.

On consideration whereof, it is now here ordered and adjudged by this Court that paragraphs 2, 5, 6 and 9 of the judgment of the District Court be, and they are hereby reversed; that paragraph 10 of the judgment be, and it is hereby vacated; that paragraphs 7 and 8 of the judgment be, and they are hereby affirmed; and the cause remanded to the District Court with directions to incorporate in the judgment a paragraph adjudging that claims 6, 10, 18 and 19 of U.S. Letters Patent No. 2,072,122 are invalid and an appropriate paragraph as to costs. Costs to defendant on each appeal.

Attest:
HARRIET G. HUMPHRYS
Chief Deputy Clerk

August 9, 1957

RULE 52 (a) OF THE FEDERAL RULES OF CIVIL PROCEDURE

Rule 52. Findings by the Court.

(a) EFFECT. In all actions tried upon the facts without a jury or with an advisory jury, the court shall find the facts specially and state separately its conclusions of law thereon and direct the entry of the appropriate judgment; and in granting or refusing interlocutory injunctions the court shall similarly set forth the findings of fact and conclusions of law which constitute the grounds of its action. Requests for findings are not necessary for purposes of review. Findings of fact shall not be set aside unless clearly erroneous, and due regard shall be given to the opportunity of the trial court to judge of the credibility of the witnesses. The findings of a master, to the extent that the court adopts them, shall be considered as the findings of the court. If an opinion or memorandum of decision is filed, it will be sufficient if the findings of fact and conclusions of law appear therein. Findings of fact and conclusions of law are unnecessary on decisions of motions under Rules 12 or 56 or any other motion except as provided in Rule 41 (b).

IN THE

Supreme Court of the United States

OCTOBER TERM, 1967

No. 680

THE COLD METAL PRODUCTS COMPANY,
Petitioner

v.

CRUCIBLE STEEL COMPANY OF AMERICA,
Respondent

ON PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE THIRD CIRCUIT

BRIEF FOR RESPONDENT IN OPPOSITION

CHARLES H. WALKER
Counsel for Respondent
Fish, Richardson & Neave
20 Exchange Place
New York 5, N. Y.

INDEX

PAGE

THERE IS NO VALID REASON FOR CERTIORARI 4

There is no question but that Rule 52(a) applies to patent cases as well as to other cases 4

The Court of Appeals did not disregard Rule 52(a) and its decision was not "contrary to all the evidence" 7

As to Montgomery Patent 2,072,122 8

As to Montgomery Patent 2,214,107 8

The decision of the Court of Appeals is not in conflict with prior decisions of this Court holding that the specification of a patent is directed to those skilled in the art 14

CONCLUSION 16

APPENDIX 1a

TABLE OF CASES

A & P Tea Co. v. Supermarket Corp., 340 U. S. 147 (1950) 4, 5

Bergman v. Aluminum Lock Shingle Corp. of America, F. 2d , 116 USPQ 32 (9 Cir. 1957) 7

Black Diamond Co. v. Excelsior Co., 156 U. S. 611 (1895) 6

Carnegie Steel Company v. Cambria Iron Company, 185 U. S. 403 (1902) 14

Cold Metal Products Co. v. Crucible Steel Co., 247 F. 2d 241 (3 Cir. 1957) 8

Cold Metal Products Co. v. Newport Steel Corp., 119 F. Supp. 880 (E. D. Ky. 1954), affirmed 226 F. 2d 19 (6 Cir. 1955) 2

Coupe v. Royer, 155 U. S. 565 (1895) 6

PAGE

Duff v. *Sterling Pump Co.*, 107 U. S. 636 (1882) 6

Graver Mfg. Co. v. *Linde Co.*, 336 U. S. 271 (1949) 4

Kiwi Coders Corp. v. *Acro Tool & Die Works*, F. 2d , 116 USPQ 2 (7 Cir. 1957) 6
Kohn v. *Eimer*, 265 Fed. 900 (2 Cir. 1920) 15

McLouth Steel Corp. v. *Cold Metal Products Co.*, 145 F. Supp. 81 (E. D. Mich. 1956), affirmed F. 2d (6 Cir. 1958) 1, 2
Minerals Separation, Limited, et al. v. *Hyde*, 242 U. S. 261 (1916) 14

O'Brien v. *O'Brien*, 202 F. 2d 254 (7 Cir. 1953) 5

Plax Corporation v. *Precision Extruders*, 239 F. 2d 792 (3 Cir. 1957) 6
R. M. Palmer Co. v. *Ludens, Inc.*, 236 F. 2d 496 (1956) 7

Seabury v. *Am Ende*, 152 U. S. 561 (1894) 14
Scott Paper Co. v. *Marcalus Co.*, 326 U. S. 249 (1945) .. 6
Singer Co. v. *Cramer*, 192 U. S. 265 (1904) 6

The Telephone Cases, 126 U. S. 1 (1888) 14
Trager v. *Crest Specialty*, 184 F. 2d 577 (7 Cir. 1950), reversed 341 U. S. 912 (1951) 5

Wabash Corp. v. *Ross Electric Corp.*, 187 F. 2d 577 (2 Cir. 1951), cert. denied 342 U. S. 826 (1951) 6
Westinghouse v. *Boyden Power Brake Co.*, 170 U. S. 537 (1898) 6
Winans v. *New York and Erie Railroad Company*, 21 How. (62 U. S.) 88 (1858) 15

IN THE

Supreme Court of the United States

OCTOBER TERM, 1957

THE COLD METAL PRODUCTS COMPANY, *Petitioner*, v. CRUCIBLE STEEL COMPANY OF AMERICA, *Respondent*.	No. 680

ON PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE THIRD CIRCUIT

BRIEF FOR RESPONDENT IN OPPOSITION

This is a conventional suit for alleged infringement of three patents relating to rolling mills, superimposed upon a conventional suit for royalties alleged to be due under a license agreement which was in force during a portion of the period with which the case is concerned.

Each of the patents has been held to be invalid for lack of patentable invention by the Court of Appeals of two different Circuits: by the Court of Appeals for the Sixth Circuit in *McLouth Steel Corp.* v. *Cold-Metal Products Co.* (decided January 9, 1958 and not yet reported*) as well as by the Court of Appeals for the Third Circuit in the present case.**. Thus there is complete unanimity, and no conflict

*A copy of the opinion is reproduced as an appendix to this brief. The opinion of the District Court which it affirmed is reported at 145 F. Supp. 81 (E. D. Mich. 1956).

**Reported at 247 F. 2d 241, and also reproduced as an appendix at pages 1a-18a of the petition, to which our references to the opinion will be cited.

Our references to the record will be made in the same form as that adopted in the petition.

of decision between Circuits, that each of the patents is invalid.

Nor is there any conflict of decision between Circuits as to any issue of infringement, the courts in the Sixth Circuit case having had no occasion to pass on that issue.

Each of the patents has expired.

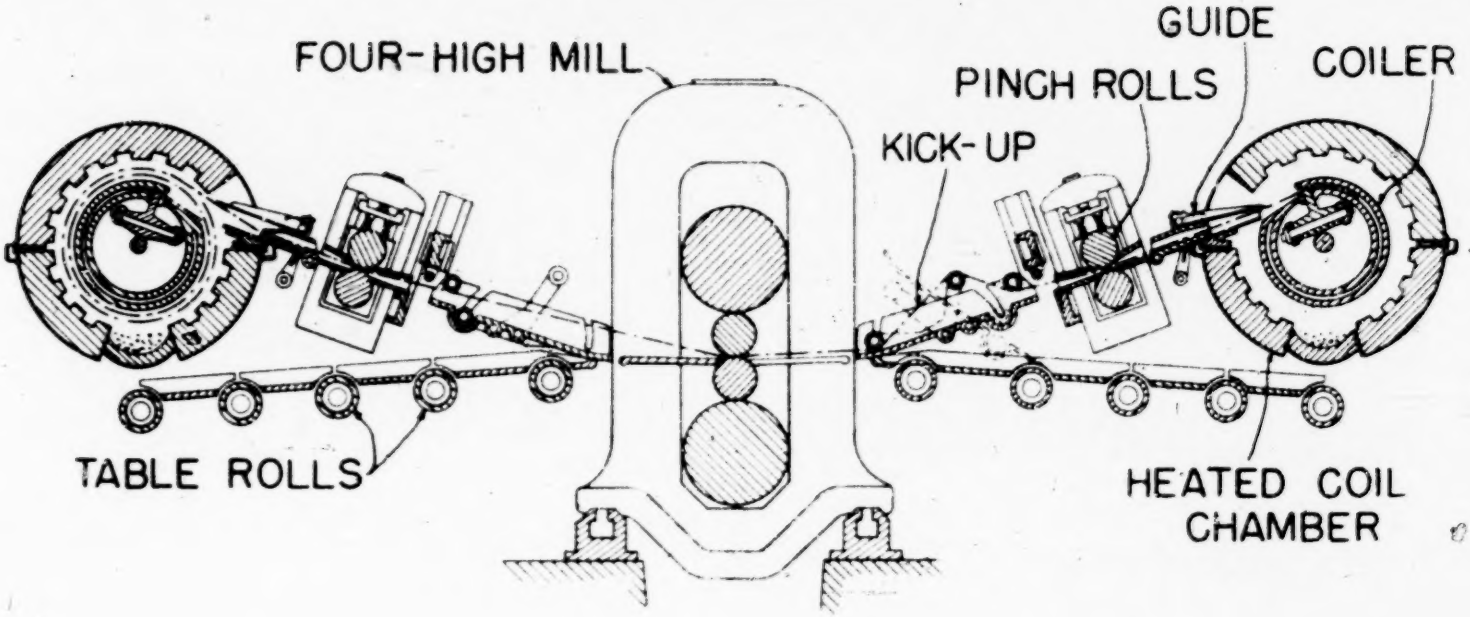
The petition seeks review of holdings by the Court of Appeals for the Third Circuit that certain claims of one of the patents (Montgomery 2,072,122) are invalid and that respondent's mill does not fall within the scope of these claims, or of one of the claims of another of the patents (Montgomery 2,214,107).

The background of the case is well stated in the Court of Appeals opinion (pp. 1a-3a). It will be noted that respondent has already paid substantial tribute (over $850,000) to petitioner for the use of earlier basic patents (Steckel 1,977,214 and Keeney & Ferm 1,918,968)*, whose expiration prior to the period in issue here entitled all the world, including respondent, to use their subject matters freely, provided only that the user refrain from using the detailed improvements to which the patents now in issue are directed.

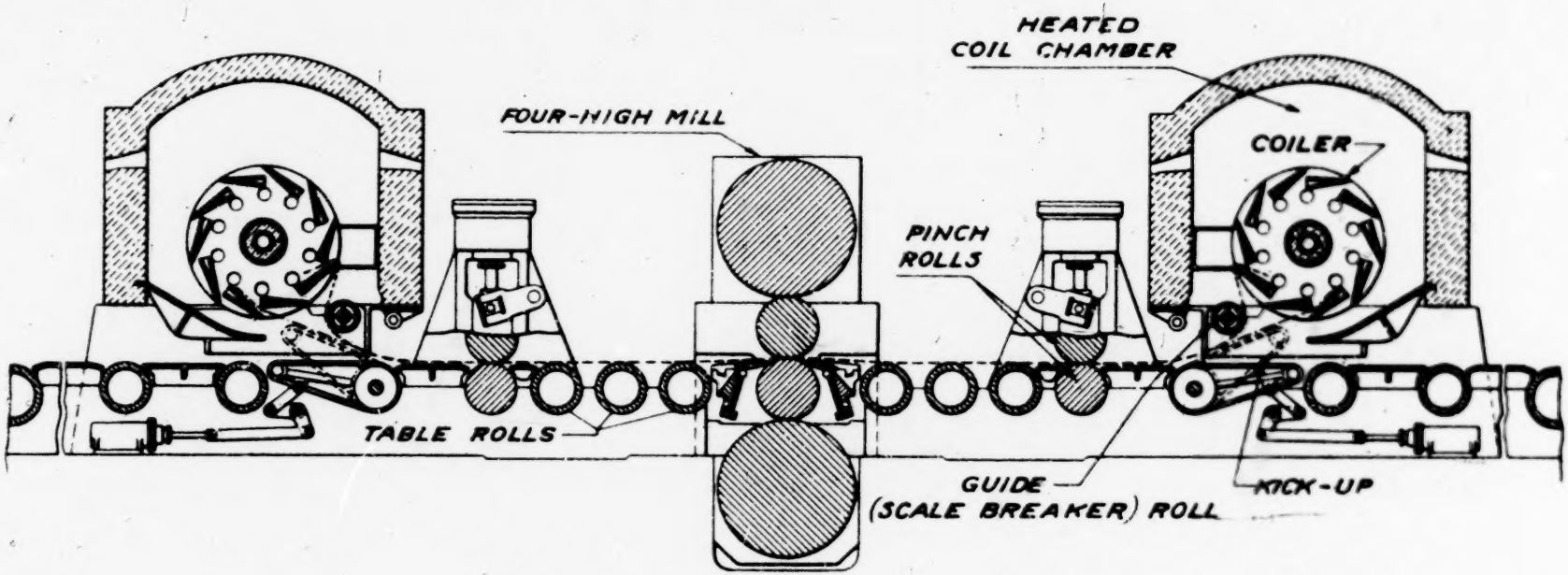
The close relationship between respondent's mill and the expired patents to which tribute has already been paid will be apparent from the chart on the facing page.

*These patents have themselves been held to be invalid by every court which has passed upon them: *Cold Metal Products Co.* v. *Newport Steel Corp.*, 119 F. Supp. 880 (E. D. Ky. 1954), affirmed 226 F. 2d 19 (6 Cir. 1955) and *McLouth Steel Corp.* v. *Cold Metal Products Co.*, 145 F. Supp. 81 (E. D. Mich. 1956), affirmed by the January 9, 1958 opinion above referred to.

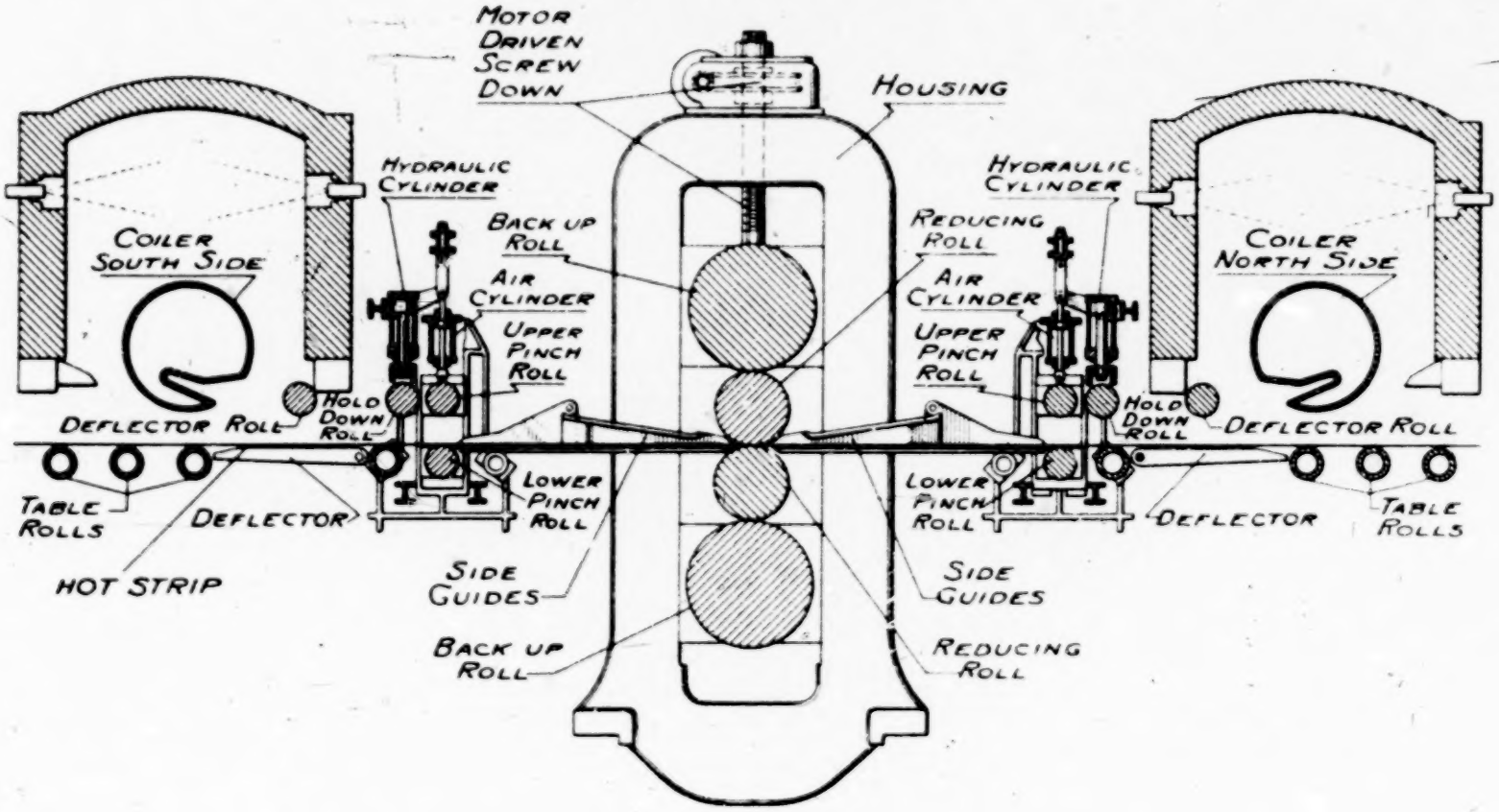
The Keeney & Ferm Mill
(R. App. 82b)



The Steckel 214 Mill
(R. App. 83b)



The Crucible Mill in Issue
(R. App. 84b)



THERE IS NO VALID REASON FOR CERTIORARI

Because of overlapping and confusion in petitioner's statement of the reasons relied upon for the granting of the writ (Petition, pp. 19-20), we regroup petitioner's reasons in this way:

1. That there is uncertainty, created by this Court's decision in *A. & P. Tea Co.* v. *Supermarket Corp.*, 340 U. S. 147 (1950), as to whether Rule 52(a) of the Federal Rules of Civil Procedure is applicable to patent cases (Reason 1);
2. That the Court of Appeals in the present case disregarded Rule 52(a) and hence that its decision is in conflict with the decisions of the Courts of Appeal of other circuits which apply that rule to patent cases (Reason 1) and with the decision of this Court in *Graver Mfg. Co.* v. *Linde Co.*, 336 U. S. 271 (1949), where this Court said and held that the rule was applicable to patent cases (Reason 2);
3. That the decision of the court below was "contrary to all of the evidence" and hence "such a departure from the accepted course of judicial proceedings as to call for this Court's supervision" (Reason 3);
4. That the decision of the court below is in conflict with prior decisions of this Court holding that the specification of a patent is directed to those skilled in the art (Reason 4).

These contentions are wholly without merit, as we shall now show.

There is no question but that Rule 52(a) applies to patent cases as well as to other cases

In *Graver Mfg. Co.* v. *Linde Co.*, 336 U. S. 271 (1949), this Court expressly so held and, indeed, went further in pointing out that Rule 52(a) was particularly applicable to

a case such as the one before it since there the trial court had been in an especially advantageous position to decide the facts correctly, having been enlightened by scientific demonstrations with respect to the testimony of experts, having visited laboratories to observe actual demonstrations of welding as taught by the patent, of the welding which was accused of infringement and of various aspects of the prior art, and having viewed motion pictures of various welding operations, tests, etc. (pp. 274-5). On that basis this Court accepted the findings of underlying facts which had been made by the District Court and concurred in by the Court of Appeals. And the Court went on to hold that the facts as found "warrant a conclusion here that *as a matter of law*"* the statutory requirements of patentability had been met and, accordingly, affirmed the concurrent holdings of validity by the lower courts.

This Court's subsequent decision in *A. & P. Tea Co.* v. *Supermarket Corp.*, 340 U. S. 147 (1950) represented no departure from what was decided or said in *Graver*. In *A. & P.* the Court was again confronted with concurrent holdings of validity. Noting that the underlying facts were "little in dispute," this Court nevertheless reversed because a test of patentable invention had been applied to those facts which was not in accord with legal standards and therefore the holding of validity could not stand *as a matter of law*.**

So far as holdings of infringement are concerned, they too involve questions of law as well as fact. The construction

*Emphasis ours throughout this brief.

**Apparently the same view was again taken by this Court in reversing per curiam (341 U. S. 912) a decision of the Court of Appeals for the Seventh Circuit sustaining on the basis of the findings of the District Court a patent on a child's feeding bowl. *Frager* v. *Crest Specialty*, 184 F. 2d 577 (7 Cir. 1950). Obviously that court's expression of doubt about the applicability of Rule 52(a) in *O'Brien* v. *O'Brien*, 202 F. 2d 254, 256 (7 Cir. 1953) alluded to at page 19 of the petition, represented that court's reaction to its reversal in *Frager* v. *Crest Specialty*. But, equally obviously, the doubt was small and momentary, for the rule has nevertheless been adhered to by that court, as petitioner admits (Petition, p. 19).

to be given a claim turns *as a matter of law* on an evaluation of the patentee's alleged contribution (as set forth in his specification and as presented by him to the Patent Office) in light of the prior art. *Coupe* v. *Royer*, 155 U. S. 565 (1895); *Black Diamond Co.* v. *Excelsior Co.*, 156 U. S. 611, 618 (1895); *Singer Co.* v. *Cramer*, 192 U. S. 265, 275 (1904). A patentee's broadest claim can be no broader than his actual invention, no matter how it may be expressed, and even where a defendant is within the literal words of the claim, if he has not actually appropriated the alleged contribution there can be no infringement. *Westinghouse* v. *Boyden Power Brake Co.*, 170 U. S. 537, 568 (1898); see also *Duff* v. *Sterling Pump Co.*, 107 U. S. 636, 639 (1882). This clearly is the case where one using the device of an expired patent is alleged to infringe a later patent by that use; he is entitled, *as a matter of law*, to a holding of non-infringement. *Scott Paper Co.* v. *Marcalus Co.*, 326 U. S. 249 (1945).

We believe the law to be clear that in a patent case, as in any other case, findings of fact, especially where *directly* based on demeanor testimony essential to a determination of those facts, are not to be set aside unless clearly erroneous, as Rule 52(a) provides. But all findings are not of this kind. Some are based on documents whose meaning is clear and as to which the reviewing court is in as good position as the trial court to understand, despite testimony of "experts" alleging the meaning to be otherwise. See *infra* pp. 14-15, *Kiwi Coders Corp.* v. *Aero Tool & Dye Works*, ___ F. 2d ___, 116 USPQ 2, 6 (7 Cir. 1957) and cases there cited; see also *Plax Corporation* v. *Precision Extruders*, 239 F. 2d 792, 795-6 (3 Cir. 1957).* Other "findings" involve questions of law, such as those relating to validity or infringement. As to such "findings", a reviewing court not only may set them aside where the law has been misapprehended below, but is under a duty to do so. Rule 52(a) is not "disregarded" where, as here, a Court

*For a comprehensive discussion of "primary" and "secondary" factual inferences, see Judge Frank's concurring opinion in *Wabash Corp.* v. *Ross Electric Corp.*, 187 F. 2d 577, 598-604 (2 Cir. 1951), cert. denied 342 U. S. 830 (1951).

of Appeals believes the court below erred in *holding* certain claims to be valid and infringed.*

Shortly before its consideration of the instant case the Court of Appeals for the Third Circuit, sitting *en banc*, not only expressly recognized the applicability of Rule 52(a) to patent cases, but showed a correct understanding of its effect, stating that the appellant in such a case has "the burden of convincing us that the District Court's findings, *to the extent that they are findings of fact*, are clearly erroneous." *R. M. Palmer Co. v. Ludeus, Inc.*, 236 F. 2d 496, 498 (1956). It is in no need of being "set straight" on this point, as petitioner asserts (p. 17).

It is evident that there is no doubt about the applicability of Rule 52(a) to patent cases which requires resolving by this Court.

The Court of Appeals did not disregard Rule 52(a) and its decision was not "contrary to all the evidence"

These points (2 and 3 in our regrouped statement of the reasons relied upon, p. 4, *supra*) can best be considered together. That they are without merit is shown by a brief discussion of the aspects of the decision as to which review is sought. Preliminarily, it may be observed that the primary evidence as to the prior art, the patents in suit and the construction and operation of respondent's mill was documentary and that there were no demonstrations, visits to laboratories, motion pictures, observations of any mill in operation or otherwise, as in the *Graver* case, *supra*. The construction and operation of respondent's mill are shown in printed documents (R. App. 89b-155b; cf. P. App. 131a-175a).

*The distinction between issues of fact and law in patent cases with particular reference to this Court's *Graver* and *A. & P.* decisions is discussed in the recent case of *Bergman* v. *Aluminum Lock Shingle Corp. of America* (9 Cir. December 13, 1957), F. 2d , 116 USPQ 32, the concurring opinion of Judge Pope, 116 USPQ at 38-41 doing so in detail.

As to Montgomery Patent 2,072,422*

The claims as to which review is sought (claims 6, 18 and 19)** are concerned with the pinch rolls used to feed the strip from the mill to the coiler or vice versa. An earlier patent, Steckel No. 1,977,214 (P. App. 197a-215a) had provided pinch rolls for feeding the strip to the mill or coilers and these pinch rolls were provided with a pair of pneumatic cylinders permitting them to be "raised or lowered as desired" (P. App. 212a, lines 129-130). Since the mill of the Steckel patent was used to roll thick ingots as well as thin strip, the height to which the rolls were raised was so great that there was danger of damage when the rolls were lowered onto thin strip from that great distance (R. App. 26b). The improvement to which these claims were directed was the provision of an additional set of cylinders of shorter stroke whereby the upper pinch rolls could be raised only a short distance off the strip by using the new cylinders, or the original longer distance by using the original set of longer stroke cylinders. That is to say, these claims added a second, independent set of lifting means to those provided in the earlier patent. The claims did not specify or indicate in any way how far off the strip the rolls would be raised by either of the independent sets of lifting means, only that one would lift them higher than the other.

The Court of Appeals said of these claims (p. 8a), much as this Court did of the claims which it held to be invalid in the *A. & P.* case:

> "We are satisfied that these claims disclose an obvious expedient, the addition to the means employed by Steckel of another means of the same type to perform the same function of lifting the upper pinch rolls, but to a different and less elevated position. This was mere aggregation and in any event did not rise to the dignity of invention."

The court then went on to consider the basis on which the petitioner had succeeded in persuading the District Court

*P. App. 91a-108a.

**Reproduced in footnote 2 at page 6a of the opinion.

to sustain these claims. That was the proposition, which had been advanced by expert witnesses on behalf of petitioner, that the pinch rolls in the new position to which they were lifted by the newly added set of shorter stroke cylinders performed certain new functions of guiding the strip, etc. The court disposed of this argument in two ways. The first was to point out that while the rolls in the low-lift position *as embodied in respondent's mill while it was a licensee under this patent* had unquestionably performed such guiding functions, that these advantages and functions flowed from the fact that in that particular mill the elevation of the pinch roll when raised by the supplemental lifting cylinders was such that it remained in guiding contact with the strip and that this was really a departure from the teachings of the patent, which repeatedly described the rolls when elevated to the low-lift position as "lifted off the strip," "lifted from the material" and "lifted out of the way when there is no further need for them" (pp. 8a-9a). Said the court in effect (p. 9a), petitioner was attempting to use as arguments in support of its patent, advantages or functions which flowed from what was in fact a departure from the patent's teachings.

Thus the Court of Appeals did not reject the finding of the District Court that the advantages referred to in fact existed when the pinch roll was properly placed in relation to the strip as it was in respondent's original mill. All of the undisputed testimony to which petitioner refers at page 15 as having been the basis for this finding was directed to what the situation was in an actual rolling mill—usually respondent's—as distinguished from the teachings of the patent.

The respect in which the Court of Appeals did reject the action of the District Court was its attribution of these advantages to "these Montgomery claims" (P. App. 244a). And the Court of Appeals was entirely correct in doing so, for the claims are completely silent as to how much the rolls shall be raised when raised by the additional lifting means which Montgomery provided, and it is clear from numerous

statements in the patent specification* that they were to be lifted entirely out of contact with the strip, not merely out of pinching engagement with it as the District Court mistakenly supposed.

In disagreeing with the District Court as to the meaning of the patent, clear on its face, which it was in as good a position to read and understand as was the District Court, the Court of Appeals did reject one bit of testimony by petitioner's expert (P. App. 50a-51a; which was palpably absurd, relying instead, as it had the right to do, upon its own reading of the patent (which happened to be in accord with the understanding of respondent's expert, R. App. 70b-71b).

But the Court of Appeals decision did not rest exclusively upon its disagreement with the District Court as to how the patent should be construed for, after discussing petitioner's contention based on the District Court's interpretation, and rejecting it as a departure from the patent's actual disclosure, the court went on to give a *second* ground for its decision, saying (p. 9a)

> "*In any event* [i.e., whether the patent be read as the court read it or as petitioner ought to have it read] at this stage of the art it was an obvious expedient to introduce such a roll where it was found to be needed."

In other words, the court said that even if the patent had disclosed and taught an operation having the features and

*Note for example Montgomery's statement that after the pinch rolls have served their purpose of feeding the strip to the mill and coiler they are "*lifted off the strip*" (P. App. 104a, col. 2, line 75 to 105a, col. 1, line 4). Though this statement was made with reference to the single-lift pinch rolls of Montgomery's Fig. 4, the same thought is expressed with respect to the operation of the double-lift pinch rolls of Fig. 5. Thus, "The pinch roll on that side [the entry side] is thus *lifted from the material*" and "The cylinders 82 on the exit side of the mill thus operate to *raise the associated pinch roll from the strip*" (P. App. 106a, col. 2, ll. 12-13, 24-26). Similarly, "The automatic control of the pinch rolls on both sides of the mill insures that the strip will be advanced properly into the mill and, on emerging therefrom, into the coiler, *whereupon the pinch rolls will be lifted out of the way when there is no further need for them*" (P. App. 107a, col. 2, ll. 3-8).

advantages claimed by petitioner, it still would be an obvious expedient, not meeting, *as a matter of law*, the standard of invention required to support a valid patent.

So far as infringement is concerned, these claims were held not to cover, or be infringed by, respondent's mill for the simple and conclusive reason that prior to the period for which royalties and infringement damages were sought, respondent had removed from its mill the additional set of lifting cylinders to which these claims are directed (Opinion, pp. 9a-10a).

The District Court had been persuaded to hold the claims to be infringed because the hold-down and guiding function performed by the pinch rolls of respondent's mill in the particular position they occupied when raised by the short stroke cylinders which repondent had used while operating as a royalty-paying licensee under this patent continued to be performed by an entirely separate hold-down roll which was added by respondent to perform this function at the time its mill was reconstructed in 1951 to remove features covered by outstanding patents. The Court of Appeals was entirely correct in its statement and holding that

> "But, as we have seen, the performance of these functions by a guide roll such as Crucible installed *was disclosed by the prior art* while the performance of those functions by the pinch rolls was not taught by the patent, indeed was excluded by its teachings. And the apparatus actually disclosed in these claims of the patent, means for raising the pinch rolls through a short distance and independent means for raising them through a greater distance, was not used by Crucible after November 19, 1951. We conclude that the district court erred in holding that claims 6, 18 and 19 of Patent No. 2,072,122 were infringed by Crucible" (Opinion, p. 10a).

Respondent having removed from its mill the additional lifting mechanism to which these claims were directed, and having used instead something disclosed by the prior art, its mill was properly held, *as a matter of law*, not to be covered by these claims.

As to Montgomery Patent 2,214,107

The single claim in issue (claim 6)* was held to be invalid by both the District Court and the Court of Appeals in both this case and the *McLouth* case. No review of that holding is sought by petitioner. But petitioner does seek review of the decision of the Court of Appeals that this claim did not cover the operation of respondent's mill.

The point of this patent, so far as the single claim in issue is concerned, is the accomplishment of *absolute uniformity* of tension in the strip between the mill and the coiling reel. In an earlier patent, Steckel 1,857,670 (P. App. 181a-184a) such absolute uniformity of tension had been achieved because the strip, in its passage from the mill to the coiling reel, came in contact with nothing to create any disparity of tension. But in later patents, Keeney & Ferm and Steckel '214**, disparities had been created by the strip's contact with intervening rolls such as the pinch rolls of each of those mills, the undriven tension rolls 79, 80 and 82 of Keeney & Ferm and the undriven guide roll 99 at the entrance of the furnace in Steckel '214.

Montgomery's theory was that if the strip was required to provide the driving power for a roll, the tension in the strip on one side of that roll would be different from the tension on the other side. His remedy was to withdraw the pinch roll from the strip so as to relieve the strip from the necessity of driving it and thereby prevent this roll from creating a disparity of tension.*** He also provided the guide

*Reproduced in footnote 6 at page 14a of the opinion.

**P. App. 185a-196a and 197a-215a respectively; see also chart, p. 3, *supra*.

***It is clear not only from Montgomery's purpose, but also from his description, that in this patent, as in patent '122, the rolls were to be lifted entirely out of contact with the strip. Thus Montgomery, describing the action on the entry side, said that the pinch (and flattening) rolls 63, 64 and 65 were *"lifted off the strip"* (P. App. 122a, col. 1, ll. 29-30) or *"lifted from the material"* (P. App. 128a, col. 2, ll. 43-45). And with respect to the delivery or exit side: "The cylinders 82 on the exit side of the mill thus operate to raise

roll at the furnace entrance with a separate motor drive so as to relieve the strip from the necessity of driving it and thereby prevent this roll from creating a disparity of tension.

The basis for the Court of Appeals' holding of non-infringement (Opinion, pp. 17a-18a) was that in respondent's operation the strip between the mill and the coiling reel was in contact with two undriven rolls, one the hold-down roll which respondent added when its mill was modified, the other an undriven guide roll at the furnace entrance (exactly like that of Steckel '214), each of which exerted a frictional drag on the material and therefore created disparities in the tension on the strip of exactly the character which it was the purpose of Montgomery to avoid.

It is this holding which petitioner asserts is in conflict with respondent's admission that "... as a practical matter the tension in the Crucible strip was substantially uniform notwithstanding its contact with two undriven rolls on each side of the mill" (Petition, p. 13). This admission, which respondent has always freely made, is based on the undeniable and undenied fact that the operation of respondent's mill is not materially affected by such small disparities of tension as are introduced by requiring the strip to drive these rolls. This means that the "problem" to which Montgomery was here addressing himself was really no problem at all and that his solution represented by this claim was of no practical importance, for his sole asserted contribution lay in the elimination of these small and inconsequential disparities of tension and the attainment of theoretical perfection. Respondent, which foregoes such theoretical perfection and follows the prior art practice on which Montgomery pur-

---

the associated punch roll to the strip. The strip is thus free between the sending and uncoiling coilers except where engaged by the mill" (P. App. 128a, col. 2, ll. 50-61). Note also the statement with respect to the punch rolls on both sides of the mill (P. App. 128a, col. 2, ll. 32-45): "The automatic control of the punch rolls on both sides of the mill insures that the strip will be advanced properly into the mill and, on emerging therefrom into the coiler, wherein the punch rolls will be lifted out of the way when there is no further need for them.

ported to improve, was properly held not to infringe *as a matter of law*, notwithstanding that the tension produced by this prior art operation was "substantially uniform" for all practical purposes. It was not the theoretically perfect uniformity to which Montgomery's claim refers.

The Court of Appeals did not disregard the admission that the tension was "substantially uniform," but agreed with respondent's contention that it was nevertheless not uniform *within the meaning of this claim*. The court was correct as a matter of law in doing so, not only because of the inapplicability of the claim as a matter of words (elaborated and made more specific by the proceedings in the Patent Office*) but also because, as the court also held (p. 17a), respondent followed the procedure of the prior art rather than that of the claim.

The decision of the Court of Appeals is not in conflict with prior decisions of this Court holding that the specification of a patent is directed to those skilled in the art

The decisions to which petitioner alludes (Petition, p. 18)** are concerned with a wholly different point than that

*In distinguishing the claim in suit (then numbered 14) from Keeney & Ferm and Steckel 2214 (for some reason the even more pertinent Steckel patent 670 was not cited by the Patent Office), Montgomery pointed out that not only the pinch rolls of those prior patents *but also the undriven, non-pinching, tension rolls 79 and 80 of Keeney & Ferm* would create a disparity of tension, incompatible with the uniformity of tension with which Montgomery was concerned (Ex. D-14, p. 37). It follows that the statement of the claim that the strip is "freed" must be construed to mean that it is freed not only from any rolls in pinching engagement with it *but also from contact with any undriven rolls*. This point was made even clearer with respect to application claim 7 (Ex. D-14, p. 24) which was ultimately rewritten to become patent claim 9 (id., p. 40) and which was amended to call for "freeing the portions of the breakdown between the mill and the points of coiling *from frictional driving or retarding engagement*" (id., p. 43).

**The Telephone Cases, 126 U. S. 1, 536 (1888); Seabury v. Am. Ende, 152 U. S. 561, 567 (1894); Carnegie Steel Company v. Cambria Iron Company, 185 U. S. 403, 437 (1902); and Minerals Separation, Limited, et al. v. Hyde, 242 U. S. 261, 270 (1916).

which petitioner seeks to draw from them. The point of those cases is that if the disclosure of a patent is sufficiently complete to be understood by a man skilled in the art to which it relates (i.e. by one whose knowledge of the art enables him to fill in gaps which the patent does not disclose) its disclosure will not be held to be insufficient even if it cannot be understood by persons having no such fund of background information, such as lawyers or members of the public generally. But these cases do not say or hold or mean that a patent which is written in plain English and which relates to subject matter which a lawyer or layman can understand should, or properly can, be interpreted by a court to mean something which is plainly in conflict with what the patent says, on the basis of the testimony of some alleged expert who asserts that to him it means the opposite. Indeed, testimony by experts as to the meaning or proper interpretation of a patent whose terms are clear is an ancient abuse of their proper function, *Winans* v. *New York and Erie Railroad Company*, 21 How. (62 U. S.) 88, 100-1 (1858), and has been roundly condemned as a "burdensome impertinence," *Kohn* v. *Eimer*, 265 Fed. 900, 902-3 (2 Cir. 1920).

The fact that the Court of Appeals took the pains to read these patents for itself, and base its decision upon its own understanding of them, constitutes no basis for proper criticism, much less the charge that in doing so the court came into conflict with the cited decisions of this Court.

Conclusion

The decision of the Court of Appeals is correct and in conformity with the applicable decisions of this Court. There is no valid basis for review by this Court. Accordingly, the petition for certiorari should be denied.

Respectfully submitted.

CHARLES H. WALKER
Counsel for Respondent

CHARLES E. KENWORTHEY
RAYMOND J. MCELHANNON
RONALD F. BALL
Of Counsel

January 22, 1958.

APPENDIX

UNITED STATES COURT OF APPEALS

FOR THE SIXTH CIRCUIT

THE COLD METAL PRODUCTS COMPANY, *Appellant*, v. McLOUTH STEEL CORPORATION, *Appellee*.	APPEAL from the United States District Court for the Eastern District of Michigan.

Decided January 9, 1958.

Before ALLEN and STEWART, Circuit Judges, and BOYD, District Judge.

PER CURIAM. This case involves validity and infringement of six patents relating to reversing hot strip mills. In suit are the following claims of the following patents: Keeney and Ferm, No. 1,918,968, Claims 2, 5, 10, 11 and 16 to 26, inclusive; Steckel, No. 1,977,214, Claims 2 to 5, inclusive, 11 to 13, inclusive, 18, and 22; Montgomery, No. 2,072,122, Claims 6, 10, and 15 to 20, inclusive; Montgomery, No. 2,087,065, Claims 1 to 5, inclusive; Montgomery, No. 2,214,107, Claims 4 and 6 to 10, inclusive; Montgomery, No. 2,072,121, Claims 2 and 3. After an extended trial the district court held all the claims invalid for lack of invention. 145 F. Supp. 81 (1956).

Certain of the claims of three of the patents had been held invalid by this court in *Cold Metal Products Co. v. Newport Steel Corp.*, 226 F. (2d) 19 (1955), and as to these claims the district court relied upon that decision, finding that the evidence in the present case which was not before the court in the *Newport Steel* case did not justify a determination contrary to the latter decision. As to the remaining claims in suit, the district court made an independent

determination that they were lacking in invention.[1] Because of this disposition of the controversy the district court did not consider the issue of infringement (although the appellee conceded that certain of the claims, if valid, were infringed), nor the appellee's contention that one of the patents had been fraudulently procured.

A careful review of the record convinces us that the district court's factual findings and legal conclusions, thoroughly and clearly expressed in Judge Levin's written opinion, are free from error. That being so, it would be supererogatory for this court to essay an extended opinion, which could be little more than a paraphrase of what the district judge has written and of what has already been said by us in *Cold Metal Products Co.* v. *Newport Steel Corp.*, *supra*. See also, *Cold Metal Products Co.* v. *Crucible Steel Company of Amer.*, 247 F. (2d) 241 (1957).

The judgment of the district court is affirmed upon Judge Levin's opinion.

[1] Recently the Court of Appeals for the Third Circuit has held many of the same claims invalid. *Cold Metal Products Co.* v. *Crucible Steel Company of Amer.*, 247 F. (2d) 241 (1957).